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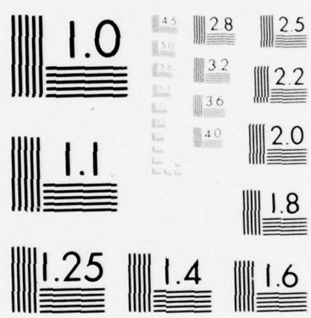

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Forecasts of Worldwide Aviation Activity

NOVEMBER 1976

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA

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U.S. DEPARTMENT OF TRANSPORTATION
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Office of Aviation Policy
Washington, D.C. 20590

Report No. FAA-AVP-76-18

FORECASTS OF AIRCRAFT ACTIVITY BY ALTITUDE, WORLD REGION AND AIRCRAFT TYPE

Randall Pozdena

November 1976

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U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C. 20590

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PREFACE

This document is a final report of the efforts of Stanford Research Institute to assist the Federal Aviation Administration in analyzing the contribution of aircraft activity to atmospheric pollution. As an element of FAA's High Altitude Pollution Program (HAPP) research, the information developed in this study is intended to provide estimates of the amount of aircraft activity that occurs over selected regions of the globe. The data provided by SRI's research effort are classified by altitude, aircraft type, and world region for 1975, 1980, 1985, and 1990. The detailed activity estimates were supplied to the FAA in hardcopy and magnetic tape format in a form suitable for emissions analysis and other research.

The data were generated by a set of models of aviation activity which simulate the interaction of suppliers and consumers of aviation services. The models use forecasts of economic and demographic variables as well as assumptions concerning the availability of new aircraft types. The flight profile exhibited by the various aircraft types is also a parameter of the models.

The research documented in this report relied partly upon previous work performed by SRI for FAA's System Research and Development Service, Satellite Branch. Specifically, this research used the econometric forecasting models and data management software previously developed to assist in evaluating satellite-based oceanic aviation support systems. Models designed to allocate aircraft activity to altitude strata, specific aircraft types, and world regions were developed especially for this research.

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The assistance and cooperation of the Federal Aviation Administration in this research is gratefully acknowledged, particularly the contributions of Mr. Bernard Hannan of the FAA's Aviation Forecast Branch, Office of Aviation Policy.

This research was conducted within SRI's Management Systems Division and the Transportation Center. The research team was led by Mr. James Gorham of the Transportation Center. Dr. Randall J. Pozdena of that group developed the aviation activity forecasting methodologies and served in the role of project leader. Mr. Robert Garnero of SRI's Naval Warfare Research Center devised the computer implementation of the models and provided valuable methodological inputs as well. Dr. John Bobick and Mr. Jerome Johnson of the Transportation Center made indirect contributions through their involvement in previous work which is drawn upon in this research effort.

I THE ACTIVITY FORECASTING MODEL

Introduction

The flight activity was forecast on an interregional basis, using models that had originally been developed for the FAA's AEROSAT analysis program. The assumptions that underlie these models are detailed in Appendix A of this report. Only flights over 400 nautical miles are considered.

Briefly, these models relate regional socioeconomic data to interregional air travel activity. The models also operate on aircraft fuel and technological data. Assumptions are made concerning the rate of increase in fuel prices and other technological aspects of providing air transport services. Gathering together these various assumptions, base and high forecast scenarios are constructed. The details of these assumptions are contained in Appendix B.

The output of these models consists of data on interregional flight frequency in the following categories of activity:

- Scheduled passenger and cargo flights
- Charter passenger flights
- General aviation flights
- Military Airlift Command (MAC) flights.

The output of the models was adapted for this research by relating all nonscheduled activity to scheduled activity by means of ratio specific to region-pairs. Then, by use of these ratios, the base-year Official Airling Guide (OAG) data could be used to provide forecasts for all categories of activity in the subsequent manipulations.

The models were also used to generate aircraft gauge (size) factors for interregional flights (in nongeneral aviation categories). This was used as an input to subsequent Aircraft Type Models and a Flight Hour Distribution Model.

The flow of input data and analysis is shown in Figure 1. The Aircraft Type Models and the Flight Hour Distribution Model are discussed in detail in the following sections.

The Aircraft Type Models

The forecasting model generates estimates of the number of flights that will occur between regions in three main categories of aircraft activity:

- Commercial activity (defined here as scheduled, civil charter, and MAC charter activity, excluding SST activity).
- SST activity.
- General aviation business jet activity.

In addition to being susceptible to different market forces, new aircraft have different possibilities of evolution in each category. In commercial aviation, the future aircraft types flown in a particular market are likely to be significantly different (in size, engine design, and so forth) from those flown today. In the SST and business jet categories of activity the evolution of aircraft types is likely to be much less significant. In the case of the SST, a second-generation version would be very unlikely to become operational during the forecast period. Business jets, also, are not likely to change significantly beyond their current configuration; the use to which they are put is limited, and the smaller overall sales volume in this industry is unlikely to support massive technological efforts.

Therefore, only the commercial activity segment of the market requires a specific model of the evolution of aircraft from their current size and configuration.

The Commercial Aviation Aircraft Model

The output of the forecasting model includes estimates of the rate of growth of the average size of gauge of commercial aircraft operating between regions. While this information is indicative of the trend in the types of aircraft that may be operating on various routes in the

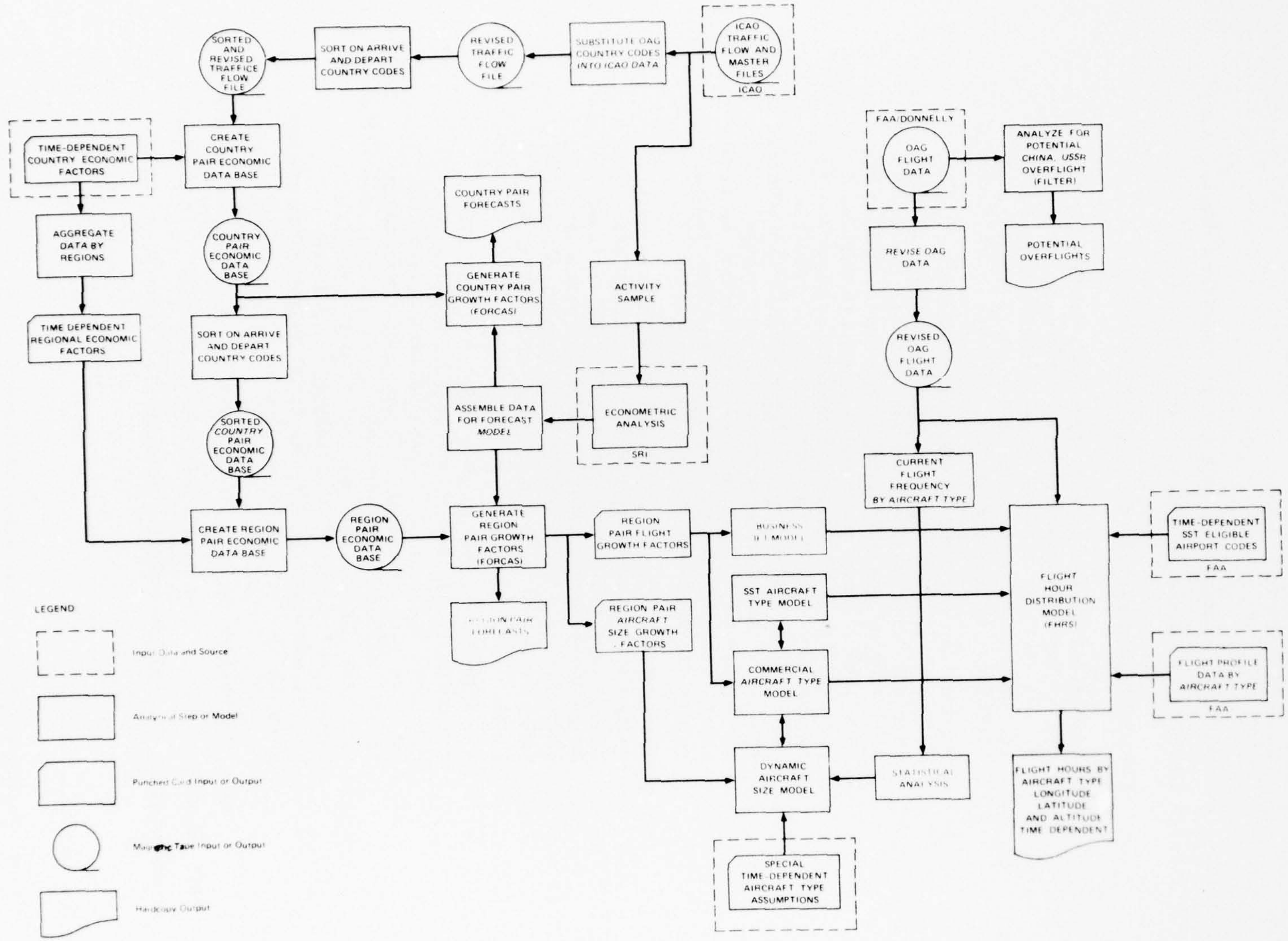

FIGURE 1 FORECASTING METHODOLOGY

future, a subsidiary procedure is required to transform these growth estimates into the evolution of specific aircraft types.

This transformation proceeds in three steps:

- Each present-day aircraft type is associated with one or more "growth variants." A growth variant is the specific type of aircraft that the operator of the current type would be likely to purchase if additional gauge were needed.
- In general, only one growth variant is associated with each current aircraft type. However, if more than one possible growth variant exists, the probabilities of the selection of the variants must be specified. There is no model procedure that will provide this information, since the presumption in having more than one growth variant is that the carriers are generally indifferent, although specific conditions may necessitate one type or another. The preference of the carrier, for example, may be to purchase a larger aircraft type from familiar manufacturers, to minimize maintenance changeover.*
- The current aircraft and their associated growth variants are then assigned to an aircraft size <u>class</u>. There are six of these classes, defined so that the growth variants of each current aircraft are in a class adjacent to the current type Table 1 shows the definition and contents of each class.
- A statistical model is then applied to calculate the probability that an aircraft of a given type will have attained its growth variant, given the forecast rate of growth of average aircraft gauge in that market. This probability is calculated each time a record is read on the Official Airline Guide (OAG) tape. The contribution of flight hours by aircraft type is then the total flight times the probability that each type is used.

The statistical model assumed a Weibull distribution of aircraft of various sizes. The parameters of this distribution were estimated by using data on the relative frequency of flights of various

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*These special aircraft type assumptions were provided by the FAA and are a special input to the models as illustrated in Figure 1.

Table 1

ASSIGNMENT OF AIRCRAFT TO GENERIC CLASSES AND SEAT CAPACITY CLASSES

Generic Aircraft Class	Seat Capacity Class*	Class Contents
L10	5	L1011
707	3	B707, DC8, B720, DC8S, B320, V10
727	3	B727, B727-200, B727F
737	2	B737, B737-200, DC9 (all series)
747	6	B747
D10	5	DC10
A3B	5	A300B
TRD	3	Trident
F28	1	F28, B11, Caravelle
T34	1	TU-104, TU-134
T54	3	TU-154, 1L-18
Y62	3	1L-62
Y86	5	1L-86
Y40	1	YAK-40
7X7	4	B7X7
74S	5	B747SP
DCX	4	DCX
LER	1	Lear jet type
CSO	1	Cessna jet type
GLF	1	Gulfstream jet type
SST	3	SST
MSC	3	All not otherwise specified

*Seat capacity classes are defined by the following approximate boundaries: Class 1 (0-80 seats), Class 2 (80-110), Class 3 (110-160), Class 4 (160-210) Class 5 (210-340), Class 6 (340+). These classifications and the aircraft assignments were largely derived from Air Transport Association classifications.

aircraft sizes found in the OAG tape of June 1975. The mean of the distribution is assumed to shift (in the direction of larger average aircraft) at the rate specified by the forecasting model. (The statistical model is described in Appendix D.) This permits calculation of the following probabilities for each forecast period:

P(A:A) = the probability that an aircraft of Class A will remain in Class A.

P(B:A) = the probability that an aircraft of Class A will be transformed to its growth variant in Class B.

For each flight segment in each forecast year (t), the level of flight hours (Y) flown by the current (Class A) and growth-variant (Class B) commercial aircraft types is then calculated from the following formulas:

$$Y_t(A) = Y_o[P(A:A)(V^A/V^A)(F_t/F_o)]$$

$$y_t(B) = Y_o[P(B:A)(V^B/V^A)(F_t/F_o)] \quad ,$$

where

Y_o is the flight hours (elapsed time) in the base year (drawn from the OAG tape) for a particular market,

V^A, V^B are the airspeeds of the current and future types, respectively,

F_t/F_o is the ratio of future to base flight frequencies (calculated in the forecasting model).

(Again, these formulas apply to all traffic except SST and general aviation, because no future variant is assumed in these markets.) In a case where there is more than one future variant, the probability of the current (Class A) aircraft growing into a specific larger type (B1) is given by

$$P(B1:A) = P(B:A)P(B1) \quad ,$$

where P(B1) is the probability of variant B1 in the growth-variant class.

The SST Aircraft Model

The SST forecasting model generates an estimate of the number of SST flights between regions, relative to the other commercial aviation activity. Using information on the elapsed time between city pairs for

which SST flights are eligible, the flight hour contributions of the SST can be calculated from the following formula:

$$Y_t^{SST} = Y_o \left[F_t^{SST}/F_o\right]\left[V^{SST}/V^o\right] \quad ,$$

where

Y_t^{SST} is the SST flight hours forecast for Year t for a particular market,

Y_o is the flight hours observed in the base year for an interregional flight,

V^{SST} is the assumed speed of the SST,

V^o is the speed of the base year equipment,

F_t^{SST}/F_o is the ratio of SST flights in Year t to the number of flights in the base year (an output of the forecasting model).

This activity required a special model based on SST demand analysis.

The analysis of the SST traffic is considerably more judgmental than the analysis that is possible for the general level of scheduled traffic. The ultimate SST service patterns will be highly dependent on the rights granted to this controversial aircraft type by the countries participating in particular routes. The institutional arrangements aside, however, considerable uncertainty exists regarding the response of the traveler to the characteristics of the SST service itself. Because the characteristics of the SST are novel, any attempt to forecast the demand for this aircraft type entails guesses and uncertainty.

Basically, the SST as currently configured in the Russian and Anglo-French versions offers the traveler a new combination of price, speed, and comfort relative to conventional airframes:

- The cruising speed of the SST is roughly twice that of conventional jets.
- The fare currently being offered is at a premium of about 20% over the standard first class fare.
- The airframes are rather narrow; coupled with the relatively short flying time, the on-board service amenities may be somewhat restricted.

- The small number of aircraft currently available limits departure frequency.
- The break-even load factor is very high because of the higher operating costs* (ameliorated somewhat by possibilities of heavier utilization on some markets because of the speeds).
- The range capabilities of the SST make it applicable mainly to routes 2500 to 3000 miles in length (or multiples thereof).

The attractiveness of the SST depends on the traveler's valuation of the service characteristics offered by the aircraft. On a 3000-mile trip, the traveler would be paying roughly $200 more than the standard economy fare (each way) to save 2.5 hours. Several studies have demonstrated that a traveler's wage is a good approximation of the value of time.[1] (See, for example, Reference 1,) Thus the traveler's wage rate would have to be roughly $80 per hour to make the time savings worth the additional expense. This assumes that conventional economy service is qualitatively similar to the SST service in other attributes; most likely, however, special gates, check-in, and other facilities will be offered by the SST carrier, which will differentiate the product somewhat in favor of the SST class of service. On the other hand, the cramped interiors of the SST are a liability to the service quality perceptions of the travelers. The net effect is uncertain, but the potential patron pool is certainly limited to a fraction of the total "regular fare" patronage. It is very likely that most of the SST patronage potential rests in the current first-class patron pool; it has been demonstrated[1] that higher time-value patrons tend to have already purchased the first class service.

Additional factors serving to limit the potential market of the SST are the high break-even factor and the limited frequency of service likely to be offered. The high break-even load factor makes the cost to

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*The useful life of the airframe is also likely to be less than that of a conventional aircraft because of stresses of speed and pressurization/depressurization.

[1] Arthur De Vany, "The Revealed Value of Time in Air Travel," Review of Economics and Statistics (February 1974).

the traveler of stochastic delay* very high. The infrequency of service makes schedule delay† costs high. Both of these factors are important in conditioning patron response to air transport services; they are particularly important to the very patron that the SST appeal is focused on, namely the traveler with a high value of time.

The maximum market share of the SST can be crudely estimated if the sensitivity of first-class passengers to time savings, fare premiums, and delay is known. The study (based on U.S. data) performed by Arthur De Vany[1] gives some indications of the elasticity of demand with respect to fare and travel time. Using his estimate of the first-class traveler's value of time of $11 per hour, the elasticities can be calculated for a trip of 3000 miles in length by using his procedures. These values are:

$$e_p = \text{fare elasticity of demand} = -1.35$$

$$e_t = \text{time elasticity of demand} = -0.29.$$

These elasticity estimates‡ can be used to estimate the fraction of first class patrons that might be diverted to SST service with its relatively higher fare and relatively lower travel time, by using a truncated form of the demand relationship. Assuming a 20% premium over

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*Stochastic delay is the additional delay that occurs when the departing flight has no available seats, so that one must wait for the next (less preferred) departure. The possibilities of experiencing stochastic delay increase with load factor.

†Schedule delay is the difference between the desired departure time and the nearest available departure time. Thus, total delay is the sum of stochastic and schedule delay. The infrequency of SST service imposes schedule delay.

‡The fare elasticity estimate is not a pure estimate of the sensitivity of travel to fares, because the flight frequency is absent from De Vany's formulation. This will overstate the sensitivity of traffic to fares, since fares and frequency of service are related through the reaction of the carrier to a lower break-even load factor as fares are raised. The reaction takes the form of additional service, which tends to "recapture" some of the traffic lost to the higher fares, making the total effect of an increase in fares less significant.

first class fares on the SST, and a saving of one-half of the travel time, the ratio of SST traffic to first-class traffic on a 3000-mile flight is equal to

$$\left(\frac{\text{SST fare}}{\text{first class fare}}\right)^{e_p}\left(\frac{\text{SST travel time}}{\text{regular jet travel time}}\right)^{e_t} = (1.2)^{-1.35}(0.5)^{-0.29}$$

$$= 0.96$$

This simple analysis indicates that the SST may potentially divert nearly all the current first class patrons. This is very likely a high-end calculation, however, since it does not embody any of the effects of stochastic and schedule delay and assumes that the "luxury" quality of service (cabin and ground amenities) is at least as high as in conventional first class service. We believe that the stochastic and schedule delay effects will substantially erode this potential base.

The diversion of a patrol pool the size of first class patronage amounts to roughly a 6% passenger diversion. This converts to nearly a 6% flight diversion because of the offsetting differences in size and load factor between the SST and the conventional aircraft it is likely to replace.*

These estimates are considerably lower than those of other observers.† Since the effect of large amounts of SST activity was of more interest to the FAA than low level activity, we used a more generous assumption in our modeling, after consultation with the FAA. We assumed that, up to the period of 1985, SST flights would represent (and divert)

*Assuming the load factor of the SST to be 90% and the seat capacity to be 100 passengers. If the prior aircraft had a 55% load factor and a seat capacity of 200, there is nearly a 1-to-1 replacement of aircraft.

†A CIAP[2] study forecast an SST fleet roughly 10% that of the world's commercial aviation fleet. Because of higher productivity of the SST this may translate into as much as 30% diversion of the flights in the markets in which it is likely to replace conventional aircraft.

[2] "Propulsion Effluents in the Stratosphere", CIAP Monograph 2, U.S. Department of Transportation, Climatic Impact Assessment Program (September 1975).

roughly 30% of scheduled flights in eligible markets.* For 1985-90, a larger fraction was assumed: 45%, in consideration of the likelihood of improved schedules availability of more aircraft, and other accelerating factors. We believe that these SST activity estimates are optimistic projections, but they serve to highlight the potential significance of SST flight hours at certain altitudes and in certain world areas.

The eligible markets were defined by selecting a list of eligible airports in the major regions likely to be served by an SST. The regions served by the SST were assumed to expand over the analysis period covered by this research in the fashion outlined in Appendix E. That appendix lists the eligible airport codes for each of the forecasting periods.

The model then applied SST flight activity to pairs of these cities. A route was declared ineligible if the stage length was less than 2000 miles.

The Business Jet Model

The forecasting model provides the ratio of business jet flights to base year flights. Flight hour data are accumulated for business jets by using an identical procedure to that described for the SST.

The assignment of business jet activity to the various aircraft types was performed by using the ratios of fleet composition in the origin countries. The assumed ratios are presented in Appendix F. Thus individual flights were assigned to these types in proportion to the fleet composition ratios. This is an approximation necessitated by the lack of superior data.

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*The diversion rate and the definition of eligible markets interact to define SST use levels. The FAA's judgment heavily influenced our work in this area. The diversion rates were defined with the given eligible markets to yield flight hour estimates based on the FAA's judgment. They should not be construed as world total diversion rates.

The flight hours estimated by these formulas for each aircraft type are also assigned to altitude and geographic location, in addition to aircraft type.

The Flight Hour Distribution Model

Allocation of Flight Hours to Altitude Strata

This research required allocation of flight hours, observed or forecast, to altitude strata:

6,000-7,999 meters

8,000-18,999 meters in 1,000-meter increments .

To allocate the estimated flight hours (by type) to altitude strata, empirical information on the flight profile of aircraft of various types was obtained from the FAA. This information enabled estimation of the probability of an aircraft (of a given type) on a route of a given stage length being at various altitudes. The information was derived from a sample of air carriers' flight behavior and was originally classified by westbound and eastbound movement. Since the vast majority of aircraft schedules are symmetric, these data were converted to directionless allocations by assigning a 50% weight to each direction.

Thus the flight hours contributed by aircraft of Type A1 at Altitude H1 for a particular forecast year can be calculated from the formula:

$$Y_t(A1,H1) = Y_t(A1)[P(H:A1,D1)] \quad ,$$

where

$Y_t(A1,H1)$ is the cruise flight hours contributed by aircraft Type A1 at Altitude H1 in forecast Year t,

$Y_t(A1)$ is the total flight hours of aircraft Type A1 in Year t.

This formula is used to calculate cruise* altitude flight hours for all the aircraft types simulated.

Allocation of Flight Hours to Geographical Area

Flight hours were allocated geographically by simulating the flight of the aircraft along a great-circle route and checking its location against the coordinates of a set of "rectangles" drawn on the face of the globe. The globe was sectioned into rectangles of dimension 10° in latitude and 40° in longitude.

The location of the aircraft is checked every 10 minutes into its simulated flight. The necessary data for this simulation (great-circle distance, elapsed time, and so on) were created from data on the OAG tapes. The 10 minutes (0.167 hour) of flight time are allocated to the rectangle in which the aircraft is located. This time is accumulated over the course of the simulation, but is allocated by aircraft type and altitude, as well, using the previously described formulas.

Ultimately, the flight hours in a particular flight record are classified by aircraft type, geographic location, and altitude. Because of the FAA's special interest in the polar regions, the flight over the poles† was separately catalogued.

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*Ascent and descent flight hours were allocated to various altitudes on different bases:

For each aircraft type, a fixed time period and rate of ascent or descent were assumed for the ascending and descending portions of the flights. Since the probability of attaining a particular cruise altitude was known from the Cruise Altitude Probabilities, the amount of time spent (probabilistically) at each altitude during ascent and descent could be calculated by using the assumed rates of ascent or descent. The total cruise flight hours were assumed to be equal to the elapsed time minus the ascent and descent times. The ascent and descent flight hours were allocated to current and variant aircraft in the same way as the cruise flight hours. The hours were allocated geographically by assuming that they all accumulated in the origin or the destination area of the globe.

†The poles are "caps" formed by the uppermost and lowermost 40° of latitude.

II ALLOWANCE FOR OVERFLIGHTS OF PEOPLE'S REPUBLIC OF CHINA AND THE SOVIET UNION

The activity generated by this research is allocated by altitude, longitude, and latitude. If air carriers were permitted to overfly the Soviet Union and the People's Republic of China (PRC) generally, the geographical dimension of this allocation process would be changed. Therefore, it was deemed important to explore the potential magnitude of overflight activity and, if necessary, to examine the impact of this eventuality on the results of the research.

The process that was applied was one based on the logic that potential overflights would come from travel activity that now originates and ends in hemispheres that straddle the USSR and the PRC. Thus, all flight activity that would not benefit from a shorter flight path could be excluded from the sample (as well as flights that currently overfly, of course). In addition, flights with an intermediate stop currently outside of the USSR and the PRC would probably eliminate that stop only if an overall flight promised a substantial savings in distance. We concluded that, if a stop were intermediate for two points less than 3000 miles apart, the flight was an unlikely candidate for a potential overflight.*

This research concluded that the overflight potential was very small and thus would not affect the geographic distribution of activity estimated by the mode. A substantial amount of flight activity already entails overflights, and the volume of activity that might benefit from new rights appeared to be small. Appendix G discusses the algorithms used to isolate potential overflight activity.

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*In addition, even if it were a potential overflight, the deviation in its route caused by elimination of the intermediate stop would not be very great if the flight were less than 3000 miles long.

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III BASE-YEAR AND FORECAST DATA

The output of this modeling effort is estimates of daily flight hour activity in various categories. The activity estimates were limited to flights longer than 400 nautical miles and were classified in the following ways:

- Aircraft type
- Altitude
- Longitude
- Latitude
- Forecast year and period
- Forecast assumptions: base and high estimates.

The detailed output was delivered to the FAA in both hardcopy and magnetic tape versions. This section summarizes the outcome of the modeling and forecasting process.

The basic flight hour data consist of a series of tables of the form presented in Table 2. These tables are specific to an aircraft type, an altitude stratum, a particular forecasting period, and a growth assumption. The table organizes the flight hour information by longitude and latitude for nonpolar activity.

In addition, a separate table is maintained for the polar activity of each aircraft type. An example is given in Table 3.

Finally, the total flight hours by aircraft type are tabulated. These data represent the daily totals for the 22 generic aircraft classes used in this research. Table 4 presents a sample of this output.

The forecasts of activity yield implications both for the type and aggregate quantity of activity that can be expected over time and for the spatial allocation of this activity. The data generated by this research are quite voluminous, and there are many classifications of activity that

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TABLE 2: SAMPLE NONPOLAR FLIGHT HOUR MATRIX

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	1.03	1.55	1.49	4.18	50.66	5.01	10.08	10.47	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.03	53.59	17.79	8.99	
-100	0.00	0.00	0.00	0.00	0.00	.14	.82	1.51	5.19	11.26	82.53	8.29	
-60	0.00	0.00	0.00	.36	3.21	2.98	2.61	3.44	3.59	3.30	39.59	109.15	
-20	0.00	0.00	0.00	.25	1.24	1.99	2.09	1.61	4.44	5.66	32.25	64.74	
20	0.00	0.00	0.00	1.33	.77	.40	.88	.93	3.50	10.91	5.50	0.00	
60	0.00	0.00	0.00	0.00	.29	.49	.97	4.34	8.23	.26	0.00	0.00	
100	0.00	0.00	.56	4.10	5.03	4.64	2.55	2.72	5.22	8.09	.39	0.00	
140	0.00	0.00	2.84	2.82	.39	0.00	0.00	0.00	3.27	27.87	23.29	11.59	
180													

TABLE 3: SAMPLE POLAR FLIGHT HOUR MATRIX

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747

	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	1.43	1.43	32.92	32.52	46.20	.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

TABLE 4: SAMPLE AIRCRAFT FLIGHT HOUR TOTALS

TOTAL FLIGHT HOURS SPENT BY AIRCRAFT TYPE

L10	881.6	707	7676.7	727	5072.0	737	2158.0	747	2974.9	D10	2094.7	A3B	23.0	TRD	157.7	
F28	390.4	T34	445.2	T54	702.3	Y62	242.7	Y86	0.0	Y40	5.4	7X7	0.0	745	0.0	
DC8	0.0	MSC	962.8	LER	602.6	C50	845.3	GLF	485.5	SST	0.0					

Note: These tables are from the June 1975 output.

may be of interest for particular issues. However, reviewing a sample* of the data provides insights to much of the data.

These results are summarized below.

Aircraft Type Evolution

The model used in this research allocates activity to aircraft of 22 generic classes. As a result of growth in traffic and the evolution of fleets to accommodate this growth economically, a shift over time occurs in the allocation of flight-hour activity to the various aircraft classes. Since practical utilization of aircraft of various types depends specifically on stage lengths, ground times, and other factors influencing utilization, it is not possible to derive the fleet data directly from the flight hour data. However, the flight hour data themselves are an indication of the evolution of activity by various aircraft types.

Table 5 illustrates the flight hour evolution generated by the model in the 1975-90 period.

It should be kept in mind that the aircraft classes used in this research are generic types rather than specifically representative of a manufacturer's types. However, Table 5 illustrates the kind of evolution that can generally be expected.

The 707 class of four-engine narrow-body aircraft will be losing its current prominence to the wider-body and new configuration aircraft, such as the L1011, 747, DC10, 7X7, and DCX classes. This is a gradual consequence of the increasing density of many markets and the presumed applicability of the 7X7 and DCX class of aircraft to the type of markets currently served by the 707 class of aircraft.

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*The forecasts based on the June 1975 data base are used in this discussion.

Table 5

DAILY FLIGHT HOURS BY AIRCRAFT TYPE AND FORECAST YEAR

Aircraft Type	1975	1980 Base	1980 High	1985 Base	1985 High	1990 Base	1990 High
Wide-body							
4-engine	2,979	4,576	5,153	7,053	9,397	10,573	16,853
3-engine	2,777	7,299	8,203	9,885	13,112	11,822	18,803
2-engine	23	168	190	326	439	515	832
Narrow-body							
4-engine	7,920	5,516	6,262	2,486	3,335	560	920
3-engine	6,327	7,896	8,885	5,117	6,775	3,668	5,871
2-engine	2,604	2,216	2,512	1,049	1,395	0	0
New configuration	0	0	0	6,875	9,037	12,641	19,794
SST	0	96	110	283	477	532	858
General aviation jet	1,937	2,455	2,621	3,162	3,486	3,990	4,642
Miscellaneous	963	1,214	1,383	1,499	2,019	1,896	1,113
Total	25,530	31,436	35,325	37,735	49,372	46,197	69,696

Note: These data represent daily totals for world activity with stage lengths greater than 400 nautical miles. The Base and High classification refers to the two traffic growth alternatives assumed in the modeling process. The data draw on a June activity base and represent the total of scheduled and non-scheduled activity in passenger and cargo traffic.

The underlying rates of growth in flight hours are apparent from the figures. Between 1975 and 1980, the compound annual rate of growth is estimated to average from 4% to 7% from the base to the high forecast case for total traffic.

The various types of traffic will, of course, grow at different rates. The general aviation activity (represented by the Learjet, Cessna, and Gulfstream classes) is projected to grow at a compound rate of growth between 5% and 6% annually. The subjective SST assumptions have produced growth rates of 17% to 21% over the 1980-90 period.

The growth rates observed for the individual aircraft classes derive from the combined consequences of the forecast model and the assumptions made concerning growth variants and applicable routes. As such, the trends summarize fairly complicated interactions within the model, and it is more difficult to associate assumptions directly with outcomes in the forecasts.

However, a very abrupt effect on the model can be seen from the introduction of the 7X7 and DCX classes in the variant lists of 1985 and 1990. Because these classes of aircraft are assumed to be future substitutes for the 707 and 727 classes of aircraft, their introduction influences the four-engine and three-engine narrow-body activity measures significantly.

For example, as Table 5 has indicated, the use of the 727 type of aircraft was forecast as growing at 5% to 7% per year between 1975 and 1980. The introduction of the DCX and 7X7 variants by 1985, however, is predicted to result in transfer of much of the 727 activity to the DCX and 7X7 because of their presumed substitutability in most cases where a larger aircraft is needed. The combined consequences of market growth and the new aircraft result in the decline of 727 usage throughout the remainder of the forecast period.

707-type usage is quite markedly influenced by the presumed availability of the DC10 and L1011 classes of aircraft as growth variants in early years, and the 7X7 in 1985 and beyond. The introduction of the IL-86 has similar effects on communist block air carrier fleets.

The 747SP (the long-range version of the 747 recently introduced) is introduced into service in the 1980 forecast period of the model by assuming a group of eligible classes and a minimum flight segment length of 4500 miles. In later periods, all carriers are presumed eligible operators of the 747SP when a 747 is forecast and an eligible flight segment exists.

As a final note, it is important to emphasize that we have tried to temper the artifically mechanical nature of our aircraft evolution modeling by as few subjective inputs as possible. This is not because of an unbridled faith in the model, but because of the phenomenal range of

assumptions that would have to be made if the modeling were to give way to a more Delphi-like process. The FAA has provided much of the input material in areas where pure modeling assumptions were unrealistic. The data relating to the aircraft type evolution are, therefore, the result of an orderly and reasoned analysis, but like all forecasts should be considered tentatively.

There have been few other attempts to forecast aircraft types in specific categories, so verification of the model by comparison with other work is difficult. The CIAP model generated a series of forecasts indicating that the "large, four-engine jet transports" would be the dominant aircraft type by 1990. Depending on the scenario, these aircraft represented 30% to 75% of the subsonic commercial fleet.

Our forecast indicates a more balanced fleet and projects that three- and four-engine wide bodies will be dominant by 1990. The CIAP model functions on a simulation principle,* while our forecast is stochastic, relying on observed fleet evolution tendencies. This might tend to make the CIAP model respond in a more discrete fashion and result in a central tendency to assign much of the traffic to a single aircraft type.

Spatial Activity Allocations

The flight hour models allocate activity to areas of the globe and to altitudes as well as to aircraft type. Roughly one-half the total cruise flight hours occur over the four global rectangles in Table 6.†

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*The CIAP model functions by assigning aircraft to routes on a cost-effectiveness basis. This simulated assignment requires assumptions of utilization, route operating costs, and other specific factors that we feel may not fully describe the optimization process an air carrier must perform.

†This table uses the 10-to-11 km altitude band as the activity basis. It excludes general aviation and SST activity and flight segments under 400 miles. The flight hours are daily totals for the June period.

Table 6

WORLD AREAS OF HIGHEST ACTIVITY

Area	1975 Flight Hours	Longitude	Latitude	Description
1	995	-140° to -100°	30° to 40°	Western U.S. and Near Pacific
2	1316	-100° to -60°	30° to 40°	Midwest and Eastern U.S.
3	938	-100° to -60°	40° to 50°	NE U.S., Canada, and Atlantic
4	509	-20° to 20°	40° to 50°	NW Europe and Atlantic

The prominence of the United States, U.S./Europe, and intra-European traffic is obvious from these data, and the basic pattern persists throughout the forecast periods of the research. The global pattern of activity is detailed in Figure 2 for 1975 and 1990. For individual aircraft the data reflect the nationality of the manufacturer and carrier and the stage length encountered in serving various areas. The base and forecast data appear to represent this well. The base year flight hours at 10 to 11 km produced by the 727, for example, represent 58% of the total in the heaviest traffic area involving the United States* but only 22% of the activity in the busiest European area.†

An illustration of the detail of the spatial allocation of flight hours for the base year is available in the sample output data set in Appendix H.

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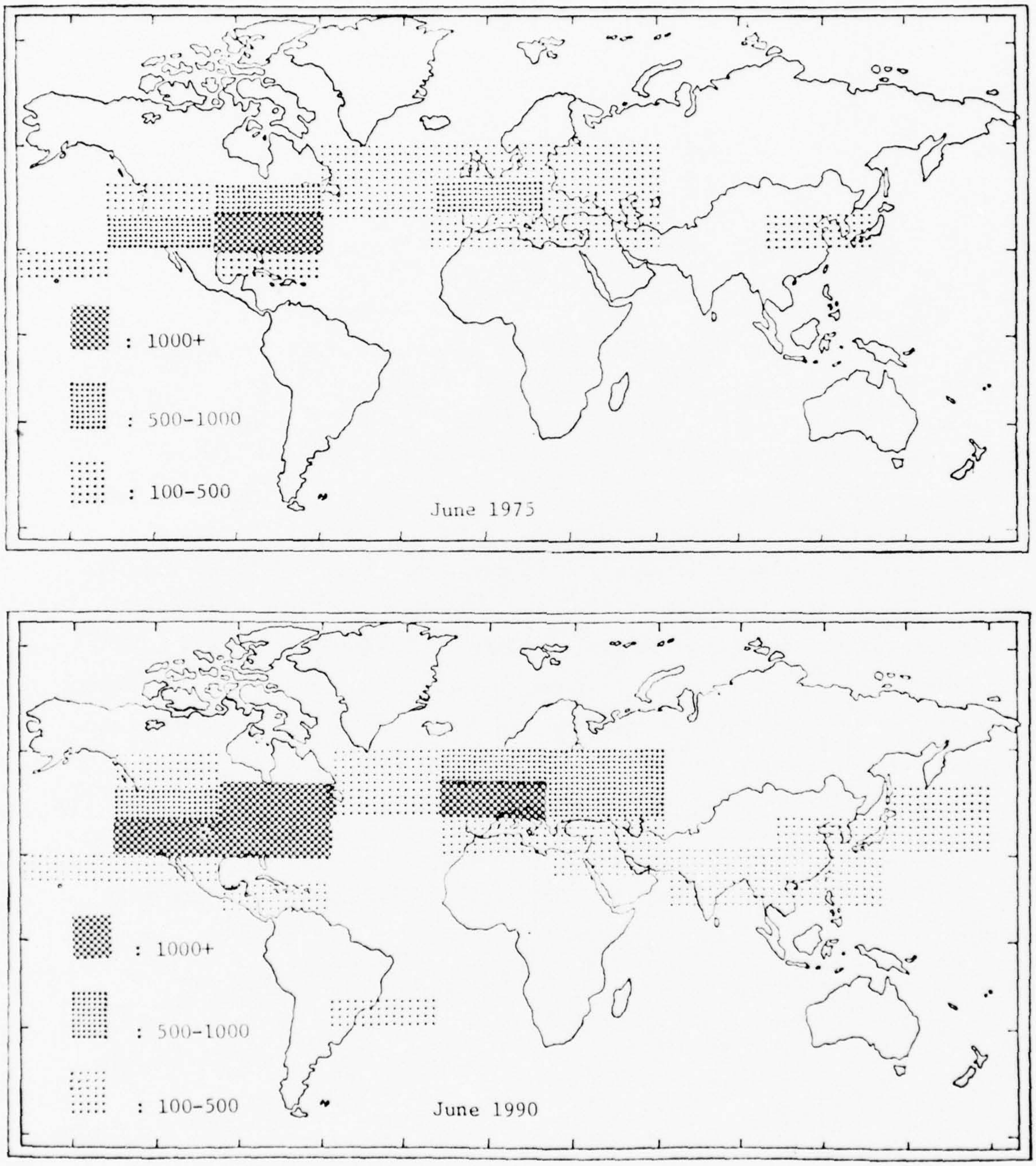
*Defined here as the rectangle bounded by -100° to -60° in longitude and 30° to 40° in latitude.

†Defined here as the rectangle bounded by -20° to 20° in longitude and 40° to 50° in latitude.



Note: The 1990 forecast in this figure is based on the Base case.

Figure 2: Comparative Daily Flight Hours for 1975 and 1990

Altitude Activity Locations

An important element of this research is the allocation of flight hours to the selected altitude strata. The likely contribution of individual aircraft types to activity at various altitudes can be discerned from the flight profile data, but the aggregate effect of combinations of aircraft types and stage lengths over a particular area of the globe must be sought in the output of the model.

Although many classifications of this activity are useful and important, it is illustrative to focus on a heavy activity region such as that encompassed by the Midwestern and Eastern United States. Table 7 indicates that commercial activity appears to be heaviest at the 10-to-11-km altitude stratum. Roughly 40% of total flight hours* occurs at this altitude. Another 40% occurs in the 8-to-10-km stratum. Consequently, over four-fifths of the total hours of activity over this area of the globe occurs in an atmospheric band less than 2 miles deep.

The disaggregated data enable summary of the altitude information by aircraft type, altitude stratum, global areas, and forecast period.

Table 7

FLIGHT HOUR ACTIVITY BY ALTITUDE STRATA

Altitude Stratum (km)	Daily Flight Hours
6- 8	203
8- 9	485
9-10	898
10-11	1314
11-12	433
12-13	99
13-14+	13

Note: These data are from June 1975, over the Midwestern and Eastern United States. General aviation activity is excluded.

*The total referred to is the aggregate flight hours that occur at an altitude over 6000 meters.

IV CONCLUSIONS AND IMPLICATIONS

The purpose of the research reported here was to provide the FAA with aircraft-specific forecasts of global activity, classified by altitude and geographical presence. The effort was restricted to flights of a stage length greater than 400 nautical miles but included nonscheduled activity in addition to flight hours generated by scheduled jets. In the models and forecasts, the general aviation activity was limited to the business jet component.

It is difficult to judge the plausibility of a forecast with so many interacting dimensions (flight hours, aircraft type, altitude, space, and time were all dimensions of this research). Moreover, a forecast of specific quantities (such as flight activity by a specific aircraft type) is a much more hazardous endeavor than an aggregate activity forecast. However, we worked with a conceptualization of the process that permits simple, unambiguous assumptions to be made to reduce the mystery of the interactions within the model. Each step of the modeling process influences the output measures, and the basic linear nature of the model makes review and criticism simple. The disaggregate data can also be aggregated to various levels when specificity is not desired.

The output of the model is plausible, at least in the fundamental sense, in that the results offer no major challenges to intuition. The allocation of the activity to altitude strata and areas of the globe is a direct consequence of the input information on flight profiles and of the use of a present-day base as the foundation of future forecast quantities. The use of actual itinerary data as the basis for the model is some assurance that the results are rooted in realistic activity measures. A simulation, on the other hand, might have aggregated any oversimplifications inherent in the model if it did not function from a real base.

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Perhaps the most crucial aspect of the forecasting process is the aircraft-tyne element of the model. Since this element controls the rate at which current aircraft types evolve into aircraft of a new configuration or gauge, it directly affects the level and atmospheric allocation of flight hour data. If a wide-body aircraft is forecast prematurely, the flight hour level will be downward biased, and the altitude locations will be distorted in the direction of the wide-body flight profile.

The predicted change in the composition of the activity from the current narrow-body jet to a wide-body aircraft is certainly not counter-intuitive, given the operating efficiencies inherent in the latter class of aircraft. Although our activity forecasts involve fairly conservative rates of growth of flight activity, the increasing demand on international segments is most certainly going to promote the selection of the larger-gauge aircraft, in addition to fostering more frequent scheduling.

Perhaps the more judgmental aspect of this aspect of the forecasting is the selection of specific aircraft types, since the growth variant lists (which are an input to the model), predetermine this evolution to a substantial degree. Here, the forecasting effort drew on the shared expertise of SRI and the FAA, but was nevertheless an uncertain element of the forecasting process. The equipment selection by individual carriers cannot be simply represented in a global, modeling context. The assumed timing of the introduction of the new aircraft types (such as the 7X7 and the DCX) is doubly perilous, since the current aircraft for which they will be further substitutes must be assumed. Errors in timing or selection of substitute aircraft types can influence the allocation of activity among aircraft significantly.

Although no forecasting process will secure the agreement of everyone in the field, the relationship between assumptions and forecast output are not completely obscured, making reanalysis and interpretation possible for those who would exploit other assumptions.

V FORECAST OF WORLD AIR CARRIER FLEET

BERNARD F. HANNAN*

After Stanford Research Institute (SRI) completed its forecasts of world aviation activity by total hours flown by equipment type, a forecast of the air carrier fleet required to produce these hours was produced by the Aviation Forecast Branch of the Federal Aviation Administration. The forecasts discussed below are for the turbojet powered aircraft of the air carrier fleet only since this was the segment of the fleet that was to be studied in this portion of the High Altitude Pollution Program (HAPP).

Several factors had to be resolved before the SRI forecasts of aircraft hours could be used to determine forecasts of the size of the air carrier fleet. As discussed before, the SRI forecasts are for air carrier flights over 400 nautical miles. The air carrier fleet forecasts are for the total fleet used at all ranges of operations. In order to accomplish this, relationships between total hours flown on segments over 400 miles to total hours flown on all segments were determined by equipment type. Also, the changing relationship in the use of equipment over time that had been determined for previous FAA studies were used in this study.

Another problem that was not completely resolved is the number and type of turbojet aircraft being used in air carrier operations by the communist bloc nations. Several sources were used for information on this subject with the principle source being "Jane's All the Worlds Aircraft."

* Aviation Forecast Branch, Office of Aviation Policy, Federal Aviation Administration

In addition to "Jane's All the Worlds Aircraft" the principle sources of information on the total world air carrier fleet for the base year of 1975 were:

1. "Aircraft Utilization and Propulsion Reliability Report" January 1975, FAA
2. "Civil Aircraft on Register" 1974, International Civil Aviation Organization
3. "U.S. and International Commercial Jet Transport Fleets" January 1975, Pratt and Whitney Aircraft
4. "World Commercial Aircraft Inventory" January 1975, McDonnell Douglas Corporation.

It was estimated from the information gained from these sources that there were approximately 9,300 aircraft being used for all types of air carrier service throughout the world during 1975. This fleet was composed of 5,489 turbojet aircraft, 2,702 turboprop aircraft and 1,085 piston aircraft. The breakdown of this fleet by equipment type is displayed in Table 8.

Using the 1975 base year fleet and the conversion of the SRI aircraft hours forecasts to total operations forecasts, a base and high forecast for the total number of turbojet aircraft to be used by the world's air carriers for the years 1980, 1985 and 1990 was prepared. The assumptions used concerning new types of aircraft to be introduced during the forecast period are shown in Table 9. These assumptions were prepared after discussions with all the major United States aircraft and engine manufacturers, most of the major U.S. air carriers, the National Aeronautics and Space Administration, and review of as many pertinent aviation publications as time would allow.

The total number of turbojet aircraft by equipment type was determined by dividing the total hours by equipment type by an average utilization per aircraft for each equipment type. The average utilizations were based on data from Civil Aeronautics Board reports and FAA reports for U.S. air carriers and information gathered from aviation publications and other sources for utilization of aircraft used by foreign air carriers.

The turbojet fleet forecast for the SRI base forecast is shown in Table 10 and the fleet for the SRI high forecast is shown in Table 11. It should be noted that in Table 5 on page 20 the number of hours for new configuration aircraft are shown separately without specifying the number of engines or body type. In the fleet forecast the new configuration aircraft have been included in the forecasts of equipment by number of engines and body type.

The number of supersonic aircraft forecast to be in operation at various points in time are based on the method explained on pages 6 through 11. It should be remembered that these forecasts are considered to be optimistic.

Table 8

World Air Carrier Fleet
January 1, 1975
TURBOJET

Wide Body		
4 Engine		
747	236	
3 Engine		
DC-10	167	
L-1011	93	
2 Engine		
A-300B	5	
TOTAL	501	

Standard Body		
4 Engine		
707/720	746	
DC-8	484	
IL-62	100	
CV-880/990	23	
VC-10	29	
Comet	21	
		1403
3 Engine		
727	1055	
Trident	80	
TU-154	150	
YAK-40	500	
		1785
2 Engine		
DC-9	703	
737	365	
Caravelle	194	
BAC-111	171	
F-28	62	
Mercure	5	
TU 124/134	300	
		1800
TOTAL		4988
TOTAL TURBOJET		5489

Table 8 (Continued)
World Air Carrier Fleet
January 1, 1975

TURBOPROP

4 Engine		2 Engine		
Electra	110	CV-580/600	141	
Hercules	28	HS-748	127	
Viscount	141	F-27	392	
Vanguard	30	YS-11	126	
Britannia	11	AN-24	700	
CL-44	31			
AN-12	300			
AN-22	20			
1L-18	550			
TOTAL	1221		1486	2702

PISTON

4 Engine		2 Engine		
DC-4/6/7	275	DC-3	490	
Constellation	9	C-46	101	
		CV-240/440	79	
		Herald	31	
		1L-14	100	
TOTAL	284			801

TOTAL TURBOJET	5489
TOTAL PROP	3792
TOTAL AIRCRAFT	9281

Table 9

World Air Carrier Fleet
Forecast New Turbojet Aircraft Through 1990

New Aircraft

Wide Body	Standard Body
4 Engine	
1L-86	
3 Engine	
7X7	
2 Engine	
DCX-200	

Super Sonic

- Concorde
- TU-144

Derivatives of Present Aircraft

Wide Body	Standard Body
4 Engine	**4 Engine**
747,747SP	None
3 Engine	**3 Engine**
DC-10	727
L-1011	YAK-40
2 Engine	**2 Engine**
A-300B	DC-9
	737
	BAC-111
	Mercure

Table 10

WORLD AIR CARRIER FLEET
TURBOJET EQUIPMENT COMPOSITION
(Base Forecast)

	1975	1980	1985	1990
Supersonic				
4 Engine		20	47	88
Wide Body				
4 Engine	236	416	771	1167
3 Engine	260	686	1185	1878
2 Engine	5	35	694	1485
Standard Body				
4 Engine	1403	1440	1091	625
3 Engine	1785	2429	2345	1873
2 Engine	1800	1908	1820	1342
Total	5489	6934	7953	8458

Table 11

WORLD AIR CARRIER FLEET
TURBOJET EQUIPMENT COMPOSITION
(High Forecast)

	1975	1980	1985	1990
Supersonic				
4 Engine		22	55	131
Wide Body				
4 Engine	236	469	1033	1887
3 Engine	260	844	1569	2971
2 Engine	5	50	1242	2273
Standard Body				
4 Engine	1403	1460	1170	904
3 Engine	1785	2626	2970	2945
2 Engine	1800	1970	1826	1590
Total	5489	7441	9865	12,701

Appendix A: FORECASTING METHODOLOGY AND ANALYSIS

To achieve the objectives of this research it was necessary to estimate or forecast five different kinds of aircraft movements. These were those associated with scheduled traffic (passenger and cargo), charter traffic [civilian and military (MAC)], and not-for-hire (general aviation) traffic. Since the OAG data on aircraft movements were used to drive our forecasting model, all other traffic and aircraft movements have been related to the scheduled traffic, through a series of interacting forecasting models. In this appendix, we describe the econometric and systems models used to forecast aircraft movements.

Traffic Forecasting Methodology

Other investigators of international air travel have tended to derive estimates of future aircraft activity by examining historical trends in aircraft movement along various routes and extrapolating traffic into the future using the calculated historical growth rates. This methodology is acceptable under severe data conditions, but does not permit incorporation of the effects of large changes in economic or institutional variables that influence air traffic and aircraft movements. SRI's work incorporates a market-derived econometric model that permits association of the changes in important variables with changes in the use of air transportation. This approach is important because of the large potential variance in certain key factors that affect air transportation, such as the price of fuel.

SRI's models are not intended to capture every detail of the behavior of air carriers on the routes, but rather to permit modeling of the

sensitivity of air carrier activity to influential forces capable of being forecast. Institutional or economic peculiarities of specific markets will affect their absolute level of activity more significantly than they will affect rates of growth. Hence, our models provide a useful analytical foundation on which to build judgment and specific market data.

This methodology is more applicable to the civilian air passenger and cargo transportation market, and less so to military air charter and not-for-hire markets. Because of their very nature, military air charter air-space demands are virtually incapable of being modeled. For both not-for-hire and military air charter markets, progressively more interpretive forecasting efforts were employed.

Forecasting Aircraft Movements Associated with Passenger Travel

The methodology for forecasting aircraft movements entails estimating the parameters of a model of the behvaior of air travelers and air carriers. In effect, the market decision process is a simultaneous interaction of demand and supply where:

- Tripmaking between two cities is influenced by the cost and frequency of flights and by qualitative service variables (say, the size of the aircraft), in addition to the demographic characteristics of the origin and destination.
- The price and frequency of service (and the size of the aircraft used)* depend, in turn, on the demand for tripmaking.

These relationships are specified in more detail below.

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*Aircraft size is also a function of the fleet composition of the carriers serving the route. Equipment purchases are dictated by system needs and compatibility, in addition to specific route requirements.

Econometrically, this interaction requires the estimation of a simultaneous equation system from observed air traffic activity data in order to discover how tripmaking and aircraft movements would change in response to forecast changes in causal variables. However, several institutional realities affect the design of the model:

- The fare is regulated through collective carrier agreements. Hence, it is a variable that is taken as given in the short run by both travelers and air carriers. It is not determined endogenously by market interactions in a continuous fashion, but is adjusted with some lag to accommodate the structure to the carriers' prior financial condition.
- The response of an air carrier through fleet changes occurs with a lag because of the nature of the planning and aircraft acquisition process faced by the air carriers.
- The limited competition in fares at any instant tends to make air carriers focus on provision of capacity as a mechanism for increasing market shares, but the bilateral agreements often constrain the capacity decisions. This leads (as will be outlined below) to conclusions about the profit maximizing behavior of the air carriers that affects the response of aircraft movements to changes in tripmaking behavior or changes in cost.

These behavioral factors must be accounted for when developing estimates of the way in which air travel and aircraft movements will change in the future. In the discussion below, we look first at demand relationships and second at supplier (air carrier) behavior.

Scheduled Passenger Travel Demand and Air Carrier Supply Modeling

The factors that condition the demand for air travel include the characteristics of the service offered (travel time, flight frequency, aircraft size, fare charged), the characteristics of the origin and destination (population, income, tourist attractions, and the like) and the purpose of the trip (business, pleasure, military).

One must consider many factors in an analysis of travel demand to explain fully the magnitude of observed tripmaking. Previous studies of air passenger travel demand have included religion, sunshine, number of historical sites, and other such data as explanatory variables. For a forecasting effort, however, the data to which travel will be correlated must themselves be capable of being forecast, and the historical data must be relatively reliable and complete. These demands on the data tend to constrain somewhat the usable range of explanatory variables. Because we were primarily interested in accuracy in forecasting changes in, rather than levels of, activity, we explored the use of those variables that have been shown in previous studies to be of primary importance in conditioning air travel demand and are, in addition, capable of being forecast. These variables included the following:

- Flight frequency
- Aircraft size
- Fare
- Distance
- Incomes at origin and destination
- Population at origin and destination
- Travel time.

Considerable evidence indicates that the demand for air travel is largely dependent upon these variables. Variables like population and income are only proxies for a variety of the attributes of origin and destination or the attributes of the traveler, but they are relatively easy to forecast compared to more complex descriptors.

We found that a concept of route capacity that combined flight frequency and aircraft size was a more significant explanatory variable than considering the variables separately. Moreover, the high correlation between distance, fare, and travel time encouraged us to eliminate the latter as a variable in the model. We also developed a novel procedure

that permitted us to estimate price elasticities using distance data rather than using the (collinear) price data directly.

The forecast development proceeded, then, from a simple model incorporating the effects of demographic and economic factors on the air carrier industry. Basically, the model consists of a passenger demand relationship and a flight cost relationship. The demand relationship relates scheduled passenger trips (Q) per period on a route to the average fare (P), the number of flights (F), the size of the aircraft (S), the product of per capita incomes in the origin and destination region (Y), and the product of populations in the origin and destination region (X).

The supply side of the market is summarized in a relationship explaining how air carrier costs are related to the flight offered. The flight cost relationship recognizes that the cost (C) of flights on a route depends on the number of flights (F), the average size of the aircraft (S), the stage length (D), and the price of fuel per gallon (G).

The air carriers are assumed to be cost-conscious in their decisions as to what size aircraft to use and what number of flights to dispatch per period. The air carriers are assumed to make adjustments in their fleet with a lag. Fares are also assumed to be adjusted by the carriers with a lag; the previous year's revenues and costs are compared, and fares are adjusted in attempts to maintain a normal profit margin.*

The entire structure system is of the form:

$$Q_t = dP_t^b \, (F_t S_t)^c \, Y^e \, X^f \quad , \tag{1}$$

---

*The model assumes a Koyck-distributed lag in the size and fare adjustment portions of the model. That is, the desired quantity and the actual quantity are adjusted using weights distributed over the previous year's information. The weights decline exponentially over time. The nearest year's weight is estimates as part of the model.

$$C_t = gF^a S^h D^i G^j \quad , \qquad (2)$$

$$\left(\frac{P_t}{P_{t-1}}\right) = \left(\frac{P^+_t}{P_{t-1}}\right)^n \quad , \qquad (3)$$

$$\left(\frac{S_t}{S_{t-1}}\right) = \left(\frac{S^+_t}{S_{t-1}}\right)^m \quad . \qquad (4)$$

In the above equations, a cross indicates the "desired" level of a variable.

Using the assumed behavioral characteristic of profit consciousness, one can derive desired levels of Q, F, S, and P in terms of the other variables by forming the project function, differentiating it with respect to the service variable, and solving for the optimum value in terms of the other variables. Relationships between these and other variables are parameterized econometrically over a sample of routes (a cross section). The econometric procedure used was the two-stage least squares procedure. This procedure was necessary because of the simultaneity of the structural equation system. The structural system was estimated in a reduced form consisting of relationships between the endogenous and exogenous variables of the system. To reduce collinearity in the system, a relationship between average fare (P) and distance (D) of the form

$$P = kD^{\ell}$$

was substituted for P. The estimated equations were of the form detailed below:

$$F = K_1 D^{A2} S^{A3} Y^{A4} \left[g^{A1} G^{A6}\right]^* \qquad (5)$$

$$Q = K_2 D^{A8} S^{A9} Y^{A10} X^{A11} \left[g^{A7} G^{A12} \right]^{*} , \qquad (6)$$

$$S = K_3 D^{A14} S_{t-1}^{A15} F^{-A16} Q^{A17} \left[g^{A13} G^{A18} \right]^{*} , \qquad (7)$$

$$C = K_4 D^{A19} S^{A20} G^{A21} , \qquad (8)$$

$$P = K_5 F^{A22} \cdot \frac{C}{Q} . \qquad (9)$$

These equations are derived from Equations (1) through (4), so:

$$A1 = \frac{b}{(a - c)}$$

$$A2 = \frac{\ell(b + 1) - i}{a - c}$$

$$A3 = \frac{c - h}{a - c}$$

$$A4 = \frac{e}{a - c}$$

$$A5 = \frac{f}{a - c}$$

$$A6 = \frac{-j}{a - c}$$

$$A7 = \frac{ab}{a - c}$$

$$A8 = \frac{\ell(ab + c) - ic}{a - c}$$

$$A9 = \frac{c(a - h)}{a - c}$$

---

*Since the data base was a cross section, these variables and their parameters did not enter in the estimation. However, their values can be determined by using the estimates of the structural parameters.

$$A10 = \frac{ea}{a - c}$$

$$A11 = \frac{fa}{a - c}$$

$$A12 = \frac{-jc}{a - c}$$

$$A13 = 0$$

$$A14 = \frac{(\ell - i)(\ell - m)}{h}$$

$$A15 = m$$

$$A16 = \frac{-a(\ell - m)}{h}$$

$$A17 = \frac{(\ell - m)}{h}$$

$$A18 = \frac{-j(\ell - m)}{h}$$

$$A19 = i$$

$$A20 = h$$

$$A21 = j$$

$$A22 = a \quad .$$

Equations (5), (6), and (7) were estimated using an instrumental variables technique. Equations (8) and (9) were estimated using ordinary least squares.

The structural parameters (a, b, c, d, and so on) can be solved using the reduced form parameter estimates (A1, A2, and so on). A sample of

transatlantic routes was used to estimate the parameters of the reduced form equations. These and the implied value of the structural parameters are tabulated in Table A-1.

Table A-1

MODEL PARAMETERS

Estimated	Derived	Economic Interpretation
A2 = -0.6277	A1 = -0.7522	--
A3 = 0.4599	A6 = -0.4144	--
A4 = 0.8636	A7 = -0.7971	--
A5 = 0.5317	A12 = -0.3337	--
A8 = -0.5918	A13 = 0	--
A9 = 1.307	A18 = -0.1013	--
A10 = 0.9359	A22 = 1.0598	--
A11 = 0.5635	a = 1.0598	Returns-to-scale factor
A14 = 0.0125	b = -0.1915	Price elasticity of demand
A15 = 0.2857	c = 0.8052	Flight elasticity of demand
A16 = -0.7300	e = 0.2199	Income elasticity of demand
A17 = 0.6687	f = 0.1359	Population elasticity of demand
A19 = 0.8713	h = 0.7436	Size elasticity of flight cost
A20 = 0.7436	i = 0.8713	Distance elasticity of flight cost
A21 = 0.1055	j = 0.1055	Fuel price elasticity of flight cost
	ℓ = 0.8843	Elasticity of fare with distance
	m = 0.2857	Fraction of undesired fleet that can be adjusted in one year

For forecast purposes, we desired a rate-of-growth forecasting format (rather than an absolute level format) of the model that would forecast the rates of growth of the endogenous variables Q, F, and S, as functions of the rates of growth of the exogenous variables Y, X, g, D, and G. Since

$$B10 = A12 + A9 \frac{(A18 - A16A6 + A17A12)}{B16} ,$$

$$B11 = \frac{(A13 - A1A16 + A17A7)}{B16} ,$$

$$B12 = \frac{(A14 - A2A16 + A17A8)}{B16} ,$$

$$B13 = \frac{(A17A10 - A16A4)}{B16} ,$$

$$B14 = \frac{(A17A11 - A16A5)}{B16} ,$$

$$B15 = \frac{(A18 - A16A6 + A17A12)}{B16} ,$$

$$B16 = (1 - A15 - A17A9 + A16A3) .$$

In addition, changes in average flight cost ($\dot{C}$), economy fare ($\dot{P}$), and average load factor ($A\dot{L}F$) can be calculated using the following equations:

$$\dot{C} = \dot{D}\ A19 + \dot{S}\ A20 + \dot{G}\ A21 + \dot{g} , \tag{13}$$

$$\dot{P} = \dot{F}\ A22 + \dot{C} - \dot{Q} , \tag{14}$$

$$A\dot{L}F = \dot{Q} - \dot{F} - \dot{S} . \tag{15}$$

Again, the "dotted" variables indicate rates of change rather than the absolute level of the variable. After normalizing the rates to the base data, these rates of growth are used to generate expected future activity levels by applying them (compounded) to a known base.

The validity of the model is evidenced in several ways. First, the estimated relationships describe the sample data with quite acceptable levels of confidence. Considering the cross-sectional nature of the

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sample, the t-statistics of the individual parameters and the coefficients of determination are very high, indicating high reliability.

Second, the estimated coefficients of the model are consistent in sign and magnitude in every case with what theory would indicate. For example, the returns-to-scale parameter (a) is roughly 1.06, indicating moderately decreasing returns to scale. This parameter value is consistent with the nature of the air carrier production process, which entails heavy outlay in flight expenses (aircraft, crew, fuel, and the like) versus ground expenses, thus making most expenses proportional to the scale of operation. The average price elasticity of demand (b) for total scheduled traffic was estimated to be roughly -0.19. This indication of low elasticity is supported by evidence from other researchers studying international air travel demand.* In addition, estimates of some parameters, such as L (the elasticity of fare with distance), while estimable via the model, are also directly estimable,† and a comparison permits an internal cross-check. The model estimates an elasticity of 0.8843, while direct estimation implies a value of 0.883. Other values, while not justifiable directly, are of a reasonable magnitude and the proper sign.

Forecasting the Dimension of Charter Air Passenger Service

Charter air passenger services have grown rapidly, particularly in the dense North Atlantic markets. The significance of charter carriers

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*See, for example, Kanafani, et al., Demand Analysis for North Atlantic Air Travel, ITTE, Special Report, University of California (April 1974). This study, performed for IATA, found elasticities of total traffic in the range of -0.1 to -0.3 for various fare types (see Table B-12).

†Fare data are not needed to estimate the model. Hence, a sterile check on the validity of the model's internal estimate of L is to estimate $P = kD^L$ directly from data on P and D from the sample used. The result was $P = 0.3198\ D^{0.883}$ ($R^2 = 0.9851$).

in the transoceanic routes is strongly dependent on the attitudes of participating countries toward such services.* With the current overcapacity that characterizes most international carriers, scheduled carriers may tend to resist the inroads of charter carrier competition while offering their own capacity at a lower rate.

If future bilateral agreements contain significant restrictions on the use of charter service, the dimension and quality of these restrictions will obviously influence the level of charter services offered and consumed. It is our expectation, however, that charter services will increasingly be negotiated as one package. Therefore charter service rights will be protected, and permitted to grow normally.

The model that is described in this report operates on the basis of OAG (Official Airline Guide) scheduled flight data when calculating the placement of aircraft over the globe. Incorporation of nonscheduled activity in the model, at the same level of precision as scheduled activity, requires flight itinerary data in a format similar to OAG data. Unfortunately, such precise data are not available for the nonscheduled portions of the market. Hence, our modeling and our activity forecasting for this segment of the market are necessarily imprecise. The theory of our approach to the analysis is discussed below.

Charter markets have evolved to permit sellers to differentiate the trip product and to sell trips to users with various tastes for price and convenience. A charter passenger is selected for his reluctance to pay high prices and his willingness (or ability) to bear the scheduling inconvenience associated with the terms of the charter passage. This fare

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*Officials of Trans-International told SRI representatives that the Japanese give preference to certificated carrier charters over charter carrier charters in aircraft landings and takeoffs at places like Tokyo. This is particularly important because the hours of operation at many points, including Tokyo, are limited by curfews.

structure is what economists call third-degree price discrimination; a small number of markets are identified, and the fares charged in each market are determined with price elasticities of the various markets in mind. The prices charged by a price discriminator are related to the elasticities of demand associated with the travelers in each market in the following fashion:

$$\frac{P_1}{P_2} = \frac{\left(1 - 1/e_2\right)}{\left(1 - 1/e_1\right)} ,$$

where

P_1 = the fare charged to Group One,

P_2 = the fare charged to Group Two,

e_1 = the price elasticity of demand of Group One,

e_2 = the price elasticity of demand of Group Two.

Thus, the higher the elasticity of demand, the lower will be the relative price charged a particular market segment. The large differences in charter and scheduled service fares are an indication of the disparity between the various markets' elasticities (the North Atlantic charter fares have been as little as one-third of the economy fare).

The industry model applied to scheduled traffic could be applied just as usefully to charter traffic. Because of the differences in patron sensitivity to price and service, the estimated parameters would be different (A1 through A22). We anticipate different rates of growth of charter activity versus scheduled activity if economic forces ultimately prevail; that is, a constant ratio of charter to scheduled passenger flight activity would not be in keeping with theoretical expectations.

Ideally, therefore, the relative level of charter and scheduled activity should be derived from a model that takes direct account of the

different sensitivities of these markets to economic forces. However, the available data did not permit separate specification and estimation of a charter model in the degree of detail offered in the scheduled model. Instead, the North Atlantic Data presented in Table A-2 were used to estimate a relative share model with the following form:*

$$R_{ij} = e^{-5.52} (Y_i Y_j)^{1.763} \quad , \qquad (16)$$

where

> R_{ij} is the ratio of charter flights to scheduled flights between i and j,
>
> Y_i and Y_j are the per capita GNPs observed at i and j, respectively, in thousands of 1973 dollars.

This model does not embrace all of the demographic forces that act upon this ratio in an environment of relatively free entry of charter services, but it does recognize the basic dependence of charter services on fairly highly developed and "wealthy" markets; for a project like air transportation services to be profitably differentiated, the market must be extensive enough to permit the simultaneous offering of a wide variety of fare and convenience/inconvenience combinations. As the size of the exponent on the GNP terms indicates, the proportion grows rapidly with growth in the potential for an extensive market. From the data, however, a saturation point appears evident even in a relatively "free" market such as the

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*The passenger data in the table were converted to flight data using passenger-per-flight information for IATA-member scheduled and charter services. The origin and destination were taken to be North America and Europe, and corresponding per capita GNP averages were developed for each of the data years. The source of the data was SRI's Long Range Planning Service (LRPS).

Table A-2

HISTORICAL LEVELS OF SCHEDULED AND CHARTER ACTIVITY IN THE NORTH ATLANTIC
(Number of Enplaned Passengers, in Thousands)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Scheduled operators												
IATA scheduled	1,760.0	1,919.5	2,272.2	2,422.2	3,069.2	3,611.3	4,197.5	4,987.4	5,258.1	5,996.8	7,201.0	7,531.9
Non-IATA scheduled Loftleidir	53.0	58.0	69.2	74.6	94.6	128.6	144.4	162.4	164.1	176.3	247.3	262.3
Total scheduled	1,813.0	1,977.5	2,341.4	2,496.8	3,163.8	3,739.9	4,341.9	5,149.8	5,422.2	6,173.1	7,448.3	7,794.2
Nonscheduled operators												
IATA nonscheduled	168.2	256.5	315.2	414.1	482.0	480.5	502.9	517.1	495.1	779.7	816.6	1,059.0
Non-IATA nonscheduled	30.0	30.0	30.0	45.0	174.0	197.5	303.0	510.0	753.0	1,499.3	2,076.0	2,403.9
Total nonscheduled	198.2	286.5	345.2	459.1	656.0	678.0	805.9	1,027.1	1,248.1	2,279.0	2,892.6	3,462.9
Total passengers	2,011.2	2,264.0	2,686.6	2,955.9	3,819.8	4,417.9	5,147.8	6,176.9	6,670.3	8,452.1	10,340.9	11,267.1

Source: Journal of Transport Economics and Policy, p. 238 (September 1973)

North Atlantic. In our forecasting efforts, R_{ij} was permitted to have a maximum value of 0.40 to reflect the observed saturation in mature charter markets.

This formulation of charter activity essentially treats the relative extent of charter activities as independent of the level of scheduled activity. Obviously, this is not precisely the case; there is some degree of substitutability between the scheduled and charter markets, and a certain portion of the observed charter traffic was diverted from scheduled service. However, some of our statistical evidence indicates that the level of substitutability is not high. For example, the scheduled demand elasticity (estimated at -0.19) is very low, indicating that the scheduled demand market is relatively insensitive to fare. Kanafani, who estimated the fare elasticity for the entire (scheduled plus charter) market, found the overall elasticity to be similar (-0.12).*

Moreover, when the level of scheduled flights is included in the formulation in Equation (16), while the coefficient is the expected negative sign (that is, as scheduled flights increase, <u>ceteris paribus</u>, charter flights decrease, and vice versa), it is much smaller than would be expected if there were one-to-one displacement of charter activity by scheduled flight activity. With a relative level of charter-to-scheduled service of between 0.10 and 0.25, the elasticity coefficient should be between -4 and -10; instead, it is only around -1.3 and, due to the small sample, is not a significant estimate.

Thus, while there is some substitutability between charter and scheduled traffic, the data do not indicate a strong relationship, and we proceeded with our forecasts using the scheduled and charter models as if they could be operated independently.

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*Kanafani et al., op. cit.

This estimated relationship between charter and scheduled flights was embedded in the forecasting portion of the model to permit differential forecasting of charter flight activity growth.

Forecasting the Dimension of All-Cargo Flight Activity

The factors influencing cargo activity are similar to those influencing passenger flight activity; the fundamental demographic factors of income and population and shipper sensitivity to tariffs and service level condition the level of activity demanded and supplied. As with charter activity, we decided to parameterize a simple model that would relate the rate of growth of cargo flight activity to the rate of growth of passenger flight activity. This decision was made because of the difficulty of parameterizing a separate, complete model in the degree of detail of the scheduled passenger service model.

Using data from IATA on the North Atlantic, we econometrically derived a relationship of the following form:

$$\dot{CGO} - \dot{SF} = 0.1136 - 0.4172\dot{S} - 1.110\dot{Y} \quad ,$$

where

$\dot{CGO} - \dot{SF}$ is the difference in the rate of growth of all-cargo flights and scheduled passenger flights,

$\dot{S}$ is the rate of growth of scheduled passenger aircraft size,

$\dot{Y}$ is the sum of the rates of growth of per capita GNP in the United States and Europe.

Using this relationship to predict the actual relative rates of growth of all-cargo and scheduled passenger flights in the North Atlantic yielded

results as follows. The difference in actual rate of growth of flights in all-cargo versus scheduled passenger service (per annum, 1962-1972) in the North Atlantic was 0.0151; the forecast was 0.0167.

This model, too, was embedded in the forecasting module of the IAC model, permitting differentiation between the forecast rates of growth of cargo and passenger flights. The cargo rate of growth was constrained to be greater than or equal to the rate of growth of scheduled flights.

Forecasting General Aviation Activity

Data on worldwide general aviation activity are not available because no system exists for collecting the data on a worldwide basis, although the FAA, the International Civil Aviation Organization (ICAO), the Aircraft Owners and Pilots Association (AOPA), the General Aviation Manufacturers Association (GAMA), and others are attempting to generate interest in developing general aviation data capability.

Most countries do not keep data on general aviation. ICAO discussed this circumstance at its last division meeting in October 1975. AOPA is trying to interest ICAO in a study of the number of pilots and hours flown in general aviation by country, and GAMA wants to expand the relevance of generation of aviation data by setting up an international organization and becoming part of ICAO. The only data on general aviation that could be supplied by ICAO are total world data (excluding the USSR and the People's Republic of China) on aircraft, pilot licenses, and flight hours (see Table A-3). Officials at GAMA and AOPA expressed some concern over the validity of even this roughly aggregated information.*

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*This overview of the state of general aviation was developed partly as a result of conversations with the following: K. Gorman, FAA; M. Murtaza, ICAO: B. Wood, GAMA; and C. S. Logsdon, AOPA.

Table A-3

TOTAL WORLD GENERAL AVIATION ACTIVITY

	1970	1971	1972	1973	1974
Aircraft (thousands)	170	197	205	219	230
Hours flown (millions)	31	33	33	36	38
Private pilot licenses (thousands)	450	470	500	530	550

Note: Excludes USSR and the People's Republic of China.

Source: ICAO

The best statistics on general aviation activity are those developed by the FAA as part of facility activity statistics and instrument flight rule traffic statistics for the U.S. Air Route Traffic Control Centers. These statistics do not, however, permit direct analysis of the pattern of general aviation activity in a manner directly amenable to incorporation in an IAC calculating procedure. Route activity data are required for such a procedure; even most of the available U.S. data are in the form of activity measures (departures, operations, overs, and the like), undifferentiated by routing characteristics of the flights except for differentiations between local and itinerant airport operations [or in the case of instrument flight rule (IFR) data, domestic and oceanic overs]. Some of the most recent data are also disturbed by the events of the recent energy crisis.*

Economic analyses of general aviation activity have been performed using U.S. data, and the level of general aviation activity in a region

*We use pre-1973 (1971) data in our statistical analyses.

has been found to be related to many of the same demographic forces that determine air carrier activity levels. Baxter and Howry,* for example, found airport general aviation activity levels in a county-by-county cross section to be related to county population, per capita income, and other area demographic quantities, in addition to factors related to the convenience of operating general aviation aircraft (the availability of airport facilities, whether or not the facility is shared with air carrier operations, and so forth).

The FAA has developed a general aviation industry model that attempts to relate activity levels to a slightly different set of demographic variables in a formulation that takes into account pilot and equipment supply variables.†

Neither the Baxter and Howry and the FAA models nor the data on which they are based are directly useful to the problem at hand; we must be able to forecast the level of general aviation activity <u>between</u> various world regions. The evidence from previous forecasting efforts suggests that a formulation for general aviation activity between two points or regions might incorporate the following insights:

- General aviation activity is, to some degree, competitive with commercial air carrier activity. We expect, <u>ceteris paribus</u>, that the level of general aviation activity in a particular market will be inversely related to the convenience and directly related to the price of commercial air carriage.
- Most probably, general aviation activity in a market is positively related to the level of economic activity at the origin and destination of the flight.

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*N. D. Baxter and E. P. Howry, "The Determinants of General Aviation Activity: A Cross-Sectional Analysis," <u>Transportation Research</u>, Vol. 2 (1968).

†See T. Henry, S. Vahovich, and J. Tom, "A General Aviation Forecasting Model," FAA (processed, March 7, 1975).

- The level of general aviation activity relative to commercial air carrier activity declines rapidly with increases in average flight distance. This is an obvious consequence of the loss of the economic viability of small-gauge aircraft when the stage length is large: The savings in convenient takeoff and arrival times are diluted over a longer total trip time; the generally shorter range of general aviation aircraft rerequires frequent refueling stops; the consumption of fuel is relatively greater; and the instrumentation required is a more significant component of aircraft utilization charges.
- The fraction of the U.S. general aviation fleet which is turbojet powered is small though growing (turbine aircraft grew from 1.95% of the fleet in 1971 to 2.38% in 1974) as shown in Table A-4.

Table A-4

RANGE CHARACTERISTICS OF THE
U.S. GENERAL AVIATION FLEET: 1971

Type	Number Registered*	Average Range of New Aircraft† (miles)
Piston		
1 engine		
1-3 places	44,637	630
4+ places	64,463	831
Multiengine	15,529	992
Turbine		
Turboprop	1,492	1,223
Turbojet	991	2,366

*From the FAA Statistical Handbook of Aviation, Table 9.4 (1972). 1971 figures were used because later data reflect the oil crisis.

†A sales-weighted average from 1970 data in Aviation Week and Space Technology (March 8, 1971).

To accommodate our forecasting efforts to the limited data available, we constructed a compromise general aviation forecasting relationship with the following form:

$$R_{ij} = aD_{ij}^{b} \left(P_i P_j\right)^{c} \left(Y_i Y_j\right)^{d} \quad , \qquad (17)$$

where

R_{ij} is the peak month level of general aviation departures between regions i and j,

D_{ij} is the distance between i and j in kilometers,

P_i is the population of origin i in millions,

P_j is the population of destination j in millions,

Y_i is the per capita income of origin i in dollars,

Y_j is the per capita income of destination j in dollars,

a, b, c, and d are parameters to be estimated.

Since no general aviation data exist on an origin/destination basis for international movements, Equation (17) could not be estimated directly, but values of the parameters could be inferred from the scant available data and some transformation of the results of previous analyses. The assumed values of the parameters and their sources are detailed in Table A-5.

Little can be done to check the validity of this formulation directly because we have no accessible information on total general aviation traffic flows between points on the globe. However, an indirect check is possible by using the model to forecast the aggregate level of U.S. domestic general aviation activity. Statistics on this activity are available from the FAA. The results of this effort are detailed below.

Table A-5

PARAMETERS OF THE GENERAL AVIATION ACTIVITY FORECASTING MODEL

Parameter	Value	Source
c d	0.37 0.74	These parameter values were adapted from the coefficients associated with similar variables in the econometric study of U.S. general aviation activity by Baxter and Howry.* Since they did not use the product formulation used in our Equation (1) their coefficients had to be divided by 2.0 to conform with the origin/destination formulation. This is legitimate, since $(P_iP_j)^{m/2} = (P_i)^m$, when $P_i = P_j$, as in their formulation.
b	-3.39	This parameter was estimated by assuming that the departure stage length distribution of general aviation flights was distributed in the same fashion as the range capabilities of the aircraft themselves. Thus, if X% of the general aviation fleet has a range capability of 2000 miles, it is assumed that flights of this length are in the same proportion to total flights. Using the data on the composition of the U.S. general aviation fleet* and data on the range characteristics of these aircraft types, a simple log linear regression was run on the number of aircraft against the range. The exponent of range is used as an approximation for b.
a	1.72×10^7 to 3.45×10^7	The value of this parameter was estimated by obtaining a professional estimate on the percentage of North Atlantic flights that had recently been classified as general aviation. The National Business Aircraft Association (NBAA) estimates that general aviation activity represents the equivalent of about 1% to 2% of scheduled activity in this market. Since in 1970 the peak month scheduled activity between North America and Europe was roughly 3000 flights in the west-east direction† and the population and per capita income of Europe and North America are known, an approximation of the parameter "a" can be solved for directly.

*See Table A-4.

†SRI-derived information from manipulation of ICAO data tapes.

The forecast and actual general aviation operations for the United States for 1971 were as follows: forecast--4,683,000 operations per peak month; actual--40,400,593 operations per year. The source of the actual operations data is the FAA Statistical Handbook of Aviation, p. 215 (1972). In converting the forecast departures to operations, the former were multiplied by two. The following values of the variables were used:

$P_i = P_j = 206.4$ (millions) [Source: SRI-LRPS] ,

$Y_i = Y_j = \$5,624.5$ [Source: SRI-LRPS] ,

$D_{ij} = 250$ kilometers [the average stage length per departure was calculated from total operations and total mileage data in the FAA Statistical Handbook of Aviation, pp. 215 and 227 (1972)].

Note: The lower value of $a = 1.72 \times 10^7$ was used in this calculation.

Reasonably close correspondence exists between forecast and actual levels of activity. While we recognize the shortcomings of such a test of the model, a preferred version requires data that are currently not available. Therefore, this research contains interregional general aviation activity forecasts that are based on the formulation described above.

Forecasting of Military Airlift Command (MAC) Charter

As was anticipated, the data available on military charter movements in the basins of interest were extremely sketchy. The Headquarters of the Military Airlift Command, Scott Air Force Base, was contacted to explore the possibility of obtaining a transformation of their activity data base into a data format of use to our counting model. Unfortunately, for reasons not clear to us, the data were not available. We did obtain, however,

aggregate statistics on the outbound and inbound passenger traffic for the Atlantic area. We were advised* to use a factor of 185 passengers per plane in converting from passenger to flight frequency estimates.

We devised an allocation procedure that used the little available subjective information to allocate this activity on a macrointerregional basis. The allocation procedure had the following format:

$$R_{ij} \quad \frac{M_{ij}T_{ij}}{N_{ij}} \quad ,$$

where

R_{ij} = the ratio of MAC flights to scheduled flights between region i and region j,

M_{ij} = the fraction of total MAC flights represented by MAC flights between i and j,

N_{ij} = the ratio of scheduled flights between i and j to the scheduled flights between the United States and Europe,

T_{ij} = the ratio of MAC flights to Europe, to scheduled traffic to Europe.

The U.S.-to-Europe base in this calculation was used because we had general evidence on the annual level of these flights. Only U.S.-to-theatre movements were assumed; no intratheatre movements were assumed.

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*By J. Reynolds, Headquarters, Military Airlift Command, Scott Air Force Base.

Appendix B

SENSITIVITY ANALYSIS OF FORECASTS OF TRAFFIC AND AIRCRAFT MOVEMENTS

As with any large scale forecasting effort, the many aspects of uncertainty at each step in the forecasting process must be assessed and their influence on the outcome evaluated. The sheer quantity of interacting variables in a study of this dimension can make sensitivity analysis difficult; the potential variation in the individual data elements is large enough so that an aggregation based on these variable microelements might be so wide-ranging as to be useless. On the other hand, because we are dealing with aggregation, the law of large numbers can work in our favor if the sensitivity analysis is performed at the aggregative or macro level. We performed sensitivity analysis on the input parameter assumptions.

Testing of Input Parameter Assumptions

Our demand modeling effort was specifically designed to reduce the number and reasonable range of parametric assumptions. Often in aviation forecasting models the fare, aircraft size, and load factor in addition to demographic variables are inputs to the model. A "reasonable" range of variation in these three parameters along with the demographic variables in a sensitivity analysis can yield a range of variation in the aggregate traffic forecasts that is so wide as to be useless in analyzing policy.

The forecasting model in this research effort does not require parametric assumptions concerning fare, load factor, or aircraft size. It functions directly from demographic and aircraft cost parameters and simulates the determination of the other three variables, thereby reducing

some unnecessary variation. The parametric variation is limited to the following variables:

- Fuel price growth rates.
- Per capita GNP and population growth rates for the origin and destination countries.
- Nonfuel cost growth rates.

All monetary quantities are in real (deflated) terms so the analysis abstracts from background levels of inflation. The assumed real rates of growth of these parameters is presented in Table B-1 below.

Table B-1

PARAMETER ASSUMPTIONS OF FORECASTING MODEL

Parameter	Scenario	For Period Ending In: 1980	1985	1990	1995
Nonfuel cost growth	H	1.0	0.0	-1.0	-2.0
	L	2.0	1.5	1.0	1.0
Gross national product growth	H	10% above the base rate			
	L	10% below the base rate			
Population growth	H	10% above the base rate			
	L	10% below the base rate			
Fuel price growth	H	1.0	0.0	0.0	0.0
	L	2.0	2.0	2.0	2.0

Notes: H = high traffic case;
L = base traffic case.

All rates of growth are on a compound annual basis.

All financial rates of growth are in real terms (in 1973 U.S. dollar values).

The base rate referred to is the rate contained in the demographic data base, using SRI sources. Where a 1990-95 rate was not forecast separately, the 1980-85 rate was assumed.

The methodology is, of course, sensitive to the assumptions made concerning these variables. If, for example, the rate of growth of real fuel prices that is assumed in Table B-1 is incorrect, this will influence the forecast growth rates. Table B-2 below shows what the effect of large errors in parameter assumptions does to the accuracy of the forecasts of flight frequency.

Table B-2

EFFECT OF A ONE-PERCENT ERROR IN THE PARAMETERS ON THE FORECAST ANNUAL RATE OF GROWTH OF SCHEDULED FLIGHTS

Parameter	Effect on Scheduled Flight Growth
Fuel price	0.5% error
Per capita GNP	0.8% error
Population	0.5% error
Nonfuel costs	0.7% error

As the table illustrates, large errors in the assumed parameters can have a significant effect on an individual forecast. If all of the parameter estimates were in error, the compound effect could be quite significant. This is a risk involved in any forecasting effort, but there are several aspects of our approach to the problem which mitigate the importance of errors:

First, the socioeconomic growth rate assumptions are developed from United Nations data which have proved useful historically.

Second, while an assumption concerning an individual country's data may be in error, since we are forecasting on a region-to-region basis, the law of large numbers suggests that aggregate forecasts will be more accurate than the data of any individual country. For example, in our assumptions concerning the growth rate of per capita GNP in Europe

(see Appendix C), we forecast annual growth rates that range from a low of 2.4% in a mature economy such as Great Britain to a high of 6.9% in younger economies such as Greece and Albania in the 1975-80 period. Being too high or too low for one individual country is not likely to be serious because there is an equal probability that we have erred in the opposite direction in another individual forecast.

Third, because we are forecasting in five-year periods rather than on a year-to-year (or month-to-month) basis, short run inaccuracy is not crucially damaging to the forecast product. Currently, for example, the United States per capita income is growing at a real rate of over 6% per annum in a post recession recovery. While our forecast (see Appendix C) over the next five years calls for an average rate of only 2.7%, this is closer to long-term trends than the current rate. A forecast based on the long-term trend is more desirable for our purposes.

The most damaging scenario (i.e., the one that the model would be most sensitive to) is one which involves a world-wide event which causes <u>all</u> of our individual market assumptions to be in error. For example, if there is a significant world-wide boom or depression in our forecast period, all of the growth rates may be in error in a uniform direction. We have accommodated this possibility in our "high" and "base" forecasts by assuming a variation in the growth rates of per capita income and population that is variously 10% higher and 10% lower than found in Appendix C.

This imposes a significant variation over a 20-year period. For example, if a country's per capita income actually grows at 8% a year over the entire 20-year period, the assumption of a 10% higher rate (i.e., 8.8% per year) and a 10% lower rate per year (i.e., 7.2%) brackets the actual level of per capita income by nearly 32% over the 20 years. While no accommodation to uncertainty is theoretically ideal,

this bracketed assumption is quite generous, particularly since it is applied to all markets over the entire 20-year period.

We allow for even more significant error in the fuel and nonfuel cost growth factors. Assumed nonfuel costs in the "low" forecast case are roughly 1.5 times as large (in deflated dollars) as those in the "high" case after 20 years.

In the case of fuel, the price of fuel in the more pessimistic base case is 1.4 times that in the optimistic case after 20 years. While there may easily be short term cases which fall outside of these bounds, we feel that this is a generous "bracketing" of assumptions over the long run.

The net effect of these assumptions is to widen the range of uncertainty somewhat. The sensitivity of the model is such that the high traffic estimate for the Atlantic basin is roughly 1.7 times that of the base estimate. Thus, in spite of relatively generous ranges of parameter assumptions, we have been able to produce controlled bounds on our traffic estimates. This is largely an advantage of the type of model that we have used which permits limiting the number of input parameters. More ad hoc models tend to generate wider bounds* which are of less utility in decision-making processes.

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*The UCLA Delphi study for the Climatic Impact Assessment Program, for example, produced high and low cases that differed by a factor of ten (USDOT, CIAP Monograph 2, 9/75, pp. 8-67).

Appendix C: FUTURE AVIATION ENVIRONMENT

The future market environment of aviation may be characterized in terms of the following attributes:

- The travel demand environment.
- The institutional environment of the air transportation market.
- The technological and resource environment of the air transportation market.

Our forecasting models have been constructed so that alternative assumptions concerning the future nature of these attributes may be directly rendered as parametric inputs to the model and the forecasting process. The purpose of this section is to describe the translation of subjective inferences about the future environment into specific parametric assumptions.

Travel Demand Environment

The demand for air transportation services is conditioned by a wide variety of economic, social, and political circumstances. The macro-influence of these forces is quite pronounced, as recent world economic events have illustrated; in 1973, with the advent of the energy crisis, real GNP growth was negligible in the OECD countries (vs. 6.3% in 1972) and world tourist arrivals fell by nearly 3%.* In addition to affecting the total propensity to travel (in relation to the propensity to perform other economic activities), these circumstances affected the relative attractiveness of certain kinds of travel and hence the travel

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*Source: OECD and the World Tourism Organization.

in specific markets. As pressures on U.S. dollars increased relative to European currencies, there was a pronounced shift in U.S.-originated traffic from European to U.S. and Latin American destinations. As political and social alliances change, the affinity felt between various world population subsegments changes. This, in turn, affects the quantity of transportation interaction observed in particular markets.

We are dealing in our forecasting effort here with the aggregative concepts of total flight hours. Because of the spatial nature of the desired estimate, significant contributions can be made by several insignificant markets. Therefore, there is no a priori sense of which are the "important" markets to be analyzed; all must be analyzed to the same degree of detail or sophistication to attain consistent sensibility in the flight hour measures derived.

In this study we are dealing with worldwide markets to which roughly 250 countries with regularly scheduled international service contribute. Since each country can conceivably be paired with every other, there are 250^2, or roughly 60,000, individual intercountry markets. Even if 90% of these could be dismissed as insignificant in themselves, as a total they determine most of the flight hours observed spatially and temporally. Thus, flight data on a city-to-city basis must be analyzed to ensure proper accounting for the spatial distribution of aircraft that may contribute to the flight hours observed over any geographic area. Since the published schedules of the world's airlines that appear in the Official Airline Guide (OAG) are the most uniform and solid basis for identifying existing intercity air movements, SRI's IAC model is driven by the detailed itinerary data available on the OAG tapes.

As is the case in any demand modeling effort, the description of the future demand environment involves uncertainty which can only be reasonably embraced by performing a sensitivity analysis on the underlying demand assumptions. With an aggregative forecasting goal, a high degree

of disaggregation compounds the sensitivity analysis problem. If the range of possible alternative futures of the demand environment for individual markets is at all large, the family of scenario combinations is extremely large, and the range of aggregated impact of the extremes of individual market assumptions may be absurdly wide.

To best accommodate these important characteristics of the analysis, therefore, SRI's forecasting model is an aggregate model rather than a micro-analytical market model. We believe that, under the constrained data, analytical, and research product circumstances, the overall result is the most credible demand modeling system for estimating worldwide aircraft activity.

Institutional Environment of the Air Transportation Market

The functioning of the international air transport industry depends on a complex set of institutional arrangements among the involved countries and their constituent carriers. These arrangements for for-hire services basically determine routes, rates, and conditions of carriage, the latter extending increasingly to the total capacity offered by carriers in particular markets and the type of aircraft that may be used.

The basic instruments for these institutional impacts are bilateral agreements between governments for the exchange of routes and on conditions of carriage and rate and related agreements reached through the International Air Transport Association. Bilateral agreements negotiated between pairs of countries are the basic instrument for exchange of air rights between them. These agreements designate the routes and pairs of points that may be served and usually the number of carriers of each country that may operate on these routes. These agreements also determine whether the authorized routes will include points in third countries either between or beyond the bilateral countries (so called fifth and sixth freedom traffic). Capacity limitations in bilaterals often are

designed to limit ability to penetrate these fifth and sixth freedom markets by tying capacity offered to the needs of direct traffic between the bilateral partners (third and fourth freedom traffic).

Most foreign carriers are wholly or partially government owned. Since bilaterals are negotiated between governments who then designate the carrier to perform the service, all international carriers are subject to considerable government influence--sometimes dictated more by overall national interests rather than the development of air transportation as such. Bilateral terms are designed to protect national carriers as well as gain rights for them and, therefore, often restrict conditions of carriage permitted to foreign airlines in ways they do not constrain national carriers.

Countries/communities also impose fees for use of airports and air navigation and traffic facilities and operating restrictions such as approach and departure paths, airports of entry, and curfews on hours of operations. Some of these are partially designed as protective of national carriers. Environmental forces have brought into sharp question the right of countries or communities/airports to impose air and noise pollution standards not covered by route bilaterals or other bilateral or international agreements, including outright prohibition on the operation of particular aircraft types such as the Concorde SST.

Some countries/airlines, particularly in Europe, have entered into pooling agreements to operate sharing schedules operated and pooling revenues. Third party carriers are excluded from carriage traffic on such routes. Even U.S. carriers--forbidden pooling agreements--have negotiated capacity restriction agreements with foreign carriers.

Bilaterals in the past have primarily established authority for operations by route type carriers. Charter carriers have had difficulties arranging service rights and have complained of discrimination in favor

of national or foreign route type operators, particularly where curfews impose some degree of rationing of entry slots. With the spread of charter operations and the increasing number of countries with national charter carriers, the prospects for inclusion of charter carrier rights in existing or separate bilateral agreements has brightened and these constraints may soon be alleviated if not completely removed. A major factor at work here is efforts to increase tourist revenues sometimes even at the expense of national carriers.

The International Air Transport Association (IATA) is the principal mechanism for the establishment of rate agreements for passengers and cargo. Since these agreements normally require government approval even where, as in the United States, the carriers are privately owned, carriers often approach IATA meetings already thoroughly briefed on what their governments will and will not accept. There is a basic conflict within IATA between carriers seeking rate structures they believe will foster long-term growth in air transportation--and these may differ on the most appropriate strategy--and those carriers/governments seeking maximization of short-term benefits such as earnings in foreign currencies. Due to the IATA unanimity rule, basic conflicts may prevent agreements and produce an open rate situation. Also, some governments may not accept IATA decisions and may instruct their carriers to establish rates not sanctioned by IATA, even to the extent of imposing them on foreign carriers. Such conflicts have led to threats of withdrawal of operating rights and other constraints (the U.K. vs the U.S. recently).

The charter carriers are not generally members of IATA even though many IATA carriers have charter carrier subsidiaries. IATA has recently acted not only to permit but to encourage charter carriers to accept some form of IATA affiliation, so far without much success. Carriers sometimes act in defiance of IATA (as in the recent--successful--case of PAA over agents' commission rates) and even drop out of IATA permanently or

for periods of time when they believe it serves their best interest. The Icelandic carrier Loftleidir is not an IATA carrier and the U.S. cargo carrier Seaboard World Airlines withdrew from membership.

Since the content and extent of international coordination of air transportation--within or outside IATA--will influence the future operating environment of the operators in important ways, our forecasting effort required an appraisal of the future nature of the institutional environment of air transportation. Our conclusions are predicated on a weakening rather than increased authority of IATA in air transport affairs and an increased tendency of government actions to permit competitive and capacity growth. We base this assumption on the generic difficulty involved in arriving at agreements among rival carriers and their governments as stakes involved in the rivalry increase. We believe that the instability of cooperative structures will increase in the future as a result of the following forces:

- As small markets grow and can accommodate more direct flight services (as opposed to feeder services), the total number of intercountry agreements will increase.
- As markets become larger and more carriers participate in providing service, the number of bilateral agreements that must be struck in each market will increase; the outcome of bargaining and negotiation is less likely to be a simulation of pure cartel tariff and capacity policies than a simulation of competitive pricing and service policies.
- Continued growth in charter operations and in the links between charter and route type operations, will strengthen the drive for provision of charter carrier rights through existing or special bilateral agreements.
- As markets become larger, the returns perceived by a "maverick" carrier investigating opportunities for increasing market share will increase. Heavy discounting or other promotional activity will have larger perceived payoffs. In a sense, the negotiation process is a gaming process, and increasing the payoff to individual players for violating cooperative strategies will increase the likelihood of noncooperative outcomes.

- While our forecasts generally predict growth in the air transport industry, growth over the next two decades will occur under unfavorable circumstances relating to energy, environment, carrier borrowing power, and airframe technology that will constrain the industry's profitability. This is likely to enhance interest in unilateral strategies as carriers strive for maintenance of market share.

These forces are already at work, of course, and are reflected in the 1974 collapse of regular sessions of the North Atlantic intergovernment price floor discussions. In the face of substantially depressed airline earnings in the previous year, the final fare package (which was not agreed on until early 1975) included lower 45-day individual excursion fares, reintroduction of youth fares in some markets, and a new, advance-purchase excursion fare.* In addition, recent estimates by IATA of the revenue "drained" by carrier noncompliance with negotiated tariff structures ranged from $100 million to $300 million annually.*

A likely outcome of a diminution of the power of coordinated economic policies on air traffic levels and flight frequency is an increase in worldwide capacity. This has proved a likely outcome of enhanced competition in the North Atlantic where significant capacity is offered by non-IATA scheduled and nonscheduled carriers. It remains to postulate the degree to which capacity would increase under a scenario involving deterioration of coordinating forces within the industry.

We approached this question two ways. First, we postulated that if there were a potential for increased competition, it would probably be strongest in markets served by a small number of carriers; larger, multicarrier markets have already been significantly invaded by what the

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*IATA, <u>Reports and Proceedings of the 31st Annual General Meeting</u>, Oslo, October 1975, p. 10.

scheduled carriers call "excess capacity"--both their own and that of nonscheduled competitors. We tested the hypothesis statistically by performing estimates of the scheduled traffic model (described in Appendix A, above) with the number of carriers serving the market as an additional variable. Thus, among markets of similar density, we would expect higher flight frequencies in those with a greater number of rival carriers. While the coefficient of this variable in our estimates was of the proper sign, the coefficient itself was statistically indistinguishable from zero, indicating that the influence was weak or perhaps lost in correlations with other variables in the formulation. Another effect at work is that small markets tend to have significant capacity offered because the governments involved are interested in promoting other, related economic activity (such as tourism and foreign exchange accumulation). Interregional service by each international carrier will normally include at least one stop in the national country. In any event, it appears that, for scheduled services, the effect of gradual "decartelization" on capacity would not be dramatic.

A greater potential exists in the addition of charter capacity as a result of the scheduled service interests' loss of power in the negotiating process. Here, we anticipate that several related developments could influence the forecast traffic levels. First, we feel that the distinction between charter and scheduled carriers will become less clear in the future, with scheduled passengers and charter passengers sharing the same aircraft; the influence of this institutional change on total flight frequency will be similar to that which would result from relatively unrestricted entry of independent charter services.* Second, we

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*The United States government is currently considering legislation to make charter (supplemental) carriers eligible for certificated route type authority without losing certificated charter rights and vice versa for carriers holding route-type certificates.

feel that the intergovernment service and fare agreements will permit relatively unrestricted participation of charter carriage in the marketplace. While it will continue to be distinguished from the low-elasticity economy and first-class fare markets, by affinity, layover, or other restrictions, we believe that charter will come to be viewed as another rate service that is complementary to rather than competitive with scheduled services.

We have embedded these institutional assumptions in our model by permitting growth in the nonscheduled passenger market to follow a pattern (in relation to the overall demographics of the market) that was statistically developed for the Atlantic scheduled traffic. The level of charter flight activity was given an upper bound of 40% of the forecast scheduled activity.

Other institutional impacts on the air transport industry include changes in the ground facilities charges or restrictions placed on aircraft as a result of problems such as airport congestion, environmental restrictions, and curfews. The curfew issue could not be approached directly in this research because of the difficulty and impracticality of identifying the influence of the restrictions on the approximately 40,000 separate flight plans on which our model draws. However, the current impact of curfews on airline schedule patterns in the OAG data base that drives the SRI model.

The negotiations of bilateral agreements for the exchange of air transport operating authorities are conducted very much in an atmosphere of quid pro quo. Governments involved are keenly aware that they are trading in important economic rights and strive to limit the amount of service of authorized foreign carriers to that minimum necessary to secure their reciprocal rights deemed essential for their own carriers. The net result is to limit interregional service to a small number of city pairs.

Carrier scheduling practices are also part of the institutional framework within which interregional aircraft movement patterns are determined. What is controlling is not the total traffic available in particular markets. It is how the carriers decide to schedule service to accommodate this traffic within the constraints and limitations imposed by bilateral agreements on routes, rates and conditions of carriage and IATA agreements. Scheduling of aircraft type and size and the timing of schedules are also affected by the location, availability, and service requirements of fifth and sixth freedom traffic that may be carried on the same or connecting schedules. Scheduling is also affected by curfews and other operating restrictions and by time zone differentials.

To optimize load factors, carriers seek to size aircraft and schedules to expected loads and to assemble loads that will closely match the capacity of the aircraft operated. This drive affects charter as well as route type scheduling and tends to limit service to a few collection points. Thus, the combination of institutional factors--bilaterals, curfews, and carrier scheduling objectives--tends to concentrate traffic flows and over-ocean aircraft movements to a limited number of route segments, with traffic collected and distributed over significant geographic regions at each end of the movement.

The number of these routings may be expected to increase in the future, but the basic flight paths and routings will be only marginally affected during our 20-year forecast period.

Technological and Resource Environment of Air Transportation

Aircraft technology and operating resources will also have important influences on future aircraft operating patterns. The size and economic performance characteristics of the aircraft likely to replace some of the aircraft presently in international over-ocean service in the next 20 years will be a major factor in determining future aircraft movement counts.

Prior to the early 1970s, the air transportation industry enjoyed a position that few service industries could match; relatively rapid growth of world prosperity had created a growing demand for its services, and advances in the technology of propulsion, aircraft designs, and avionics permitted the industry to respond to this demand with a product that was increasing in quality and decreasing in price in real terms. The introduction of jet air transportation in the late 1950s and the 1960s had not only materially improved comfort and reduced transit times, it had drastically cut engine maintenance and overhaul costs and frequencies and sharply increased employee productivity.

Introduction of wide-bodied aircraft with higher bypass ratio, more fuel efficient, engines offered additional gains but these aircraft could not be used effectively to realize even their more limited increased potential because of the slackening economic growth and the impact of the oil shortage in 1973, 1974, and 1975. The advent of the oil embargo in 1973 rudely awakened the industry to the precarious nature of its techno-economic situation. Even though by dint of service curtailment and drastic fuel economy operation and maintenance programs, air carriers were able overall to carry more passengers with less fuel, and made more money in 1974, this position was not held into 1975. The combination of a slackening in the forces that condition the demand for air travel with the rise in the cost of fuel resulted in a significant drop in worldwide scheduled passenger traffic growth; in 1975 growth was only about 4% in comparison with the 7 to 10% enjoyed annually earlier in the decade.* Transatlantic air traffic that had been a poor relation in the traffic growth and revenue yield picture in 1974 was even more a disaster in 1975. It had borne the combined brunt of fuel shortages, higher than domestic fuel price increases, and over competition and capacity more heavily than

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*IATA, <u>World Air Transport Statistics</u> (1974).

at least U.S. domestic air transportation. Further complicating both domestic and international capacity/traffic (hence load factor) ratios, was the flood of deliveries of new large capacity aircraft. Aircraft types designed and ordered on the basis of traffic growth rates in the 1960s provided capacities too large for the traffic loads collectable in the 1970s. Orders by U.S. carriers, which have historically accounted for 50% of the market, are flat and it looks to be some years before new aircraft orders pick up again.

When they do, it will be important to know what kind of aircraft will be purchased and in what quantities. We do not believe that there will be a significant market for large-capacity aircraft--700-1,000 passengers--or for the present generation of SST. Nor do we believe that large new orders for whole fleets of aircraft will be placed as in the past. The ability of the air transport industry--including the manufacturing segment--to respond to air travel demands with new, innovative aircraft concepts is constrained by several limitations:

- Fuel costs and availability.
- Labor and other costs.
- Capital availability and cost.
- Ability of the carriers to finance acquisition and integration of significant numbers of new technology aircraft.*
- The ability of technology to devise aircraft which will continuously increase the productivity of increasingly expensive labor and fuel.
- The ability of the airframe and engine industries to finance both the aircraft design R&D and the production and sale of new technology aircraft.

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*For an evaluation of these issues, see J. E. Gorham et al., "The Economic Impact of Energy Shortages on Commercial Air Transportation and Aviation Manufacture," Stanford Research Institute Report for FEA (1975), NTIS Nos.: Vol. 1 - PB246-271, Vol. 2 - PB246-272.

In our forecasts we have assumed two scenarios respecting technological change and cost impacts--an "optimistic" and a "base" set of assumptions. These scenarios differ principally in the possible application of technology to improvements in fuel efficiency and other factors affecting unit operating costs, the extent of the savings that may be attained, and the timing of introduction of advanced-technology, more fuel efficient aircraft.

Optimistic Scenario--The wide range of technology available, at least on the drawing boards, could be applied to reduce fuel consumption and unit flight costs by improving propulsion and aerodynamic efficiency and lift/drag ratios. These include reduced structural weight through use of composites and other advanced materials; improved airfoil design (super-critical wing) that can reduce wing weight and lower drag; engine system improvements such as variable cycle engines; and basically more efficient structure and laminar flow control. Aircraft and engine manufacturers are exploring these concepts on their own and through DOD and NASA contracts. The government is conducting in-house research as well, primarily through NASA and DOD. Both Pratt and Whitney and GE have fuel efficient engines in the advanced design or test stage. Boeing and McDonnel Douglas have B-707/DC-8 replacements in design for the 1980s that take partial advantage of new technology. Both have made recent studies of technological possibilities independently and under NASA contracts.* Two engineers at Lockheed have suggested that advanced improvements in aerodynamics, materials, and propulsion might yield 22% reduction

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*Boeing Commercial Aviation Company, "Fuel Conservation Possibilities for Terminal Area Compatible Aircraft," Final Oral Report, Contract NAS1-12018, January 29, 1975.

R. E. Block and J. A. Stern (of Douglas Aircraft Co.), "Advanced Subsonic Transports--A Challenge for the 1990's," AIAA paper No. 75-304 (February 24, 1975).

in direct operating costs (DOC) or a saving of roughly 10 to 15% in total costs.* With rising fuel costs and the probability of continued increases, the emphasis is on increased fuel efficiency.† NASA AMES has an active contract research program on methods to increase fuel efficiency that includes three manufacturers: McDonnell Douglas, Lockheed, and United Technology Laboratories plus United Airlines. It has designed a paper "Reduced Energy Transport" (RET) whose lower swept wing and operating speed are questioned by some airlines. Nevertheless, two recent NASA papers estimate significant technological gains in fuel efficiency (measured in seat-miles per gallon) for the RET as well as for conventional aircraft.‡ Aircraft technological developments over the four five-year forecast periods under optimistic assumptions would involve the introduction of new technology aircraft as follows:

- 1975-80: This period would be characterized largely by continued employment of existing technology aircraft, with profit-sensible increases in aircraft gauge, largely involving the B-747, DC-10, L-1011, and the A-300B.
- 1980-85: In this period a B-7X7 and a DC-X-200 with an approximate 180-passenger capacity might be introduced. Another possibility is a four-engined A-300B with a new wing and fuel efficient engines (such as the GE/SNECMA, CFM-56 or P&W/RR/MTU/Fiat JT10D) with a capacity of about 210 passengers. The fuel efficiency gain of 20% would be offset somewhat by the additional cost of the improved aircraft characteristics, for an average total cost saving of 4 to 5%, including capital charges.

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*G. Sim and R. Hopps, "Commercial Transports: Decade of Derivatives," Astronautics and Aeronautics (February 1975), pp. 24-32.

†Aviation Week and Space Technology (April 28, 1975), p. 105. See also Aircraft Technology Bibliography.

‡M. D. Ardema et al. (NASA AMES) "Conceptual Design of Reduced Energy Transports," AIAA Paper No. 75-303 (February 24, 1975), Figure 14. See also A. C. Mascy and L. J. Williams (NASA AMES), "Air Transportation Energy Consumption Yesterday, Today, and Tomorrow," Paper No. 75-319 (February 24, 1976).

- 1985-1990: Further U.S.-designed advanced concept aircraft with 200-passenger, long-haul capability, supercritical airfoils, and new fuel efficient engines might be introduced. A European analog with four CFM-56/JT10D or other ten-ton engines and 200-passenger capacity in a long-haul version is another possibility. Additional average total cost savings of 4-5% over the previous period's aircraft are possible. Medium-haul designs will also take advantage of wing modifications and fuel efficient propulsion systems. These might include a BAC-111-800 with two JT10D engines, stretched to 145 passengers; a Dassault-Breguet Mercure 200-2 with CFM-56 engines and 147-passenger capacity; an AS Trident 4 with ten-ton engines and 142-passenger capacity; and U.S. B-7X7/DC-X-200 derivations.
- 1990-1995: Optimistically, this period might see the introduction of entirely new families of aircraft with total fuel savings of 10-15% over the base period.

During the forecast period, the SST would be operating over the Atlantic basin in both the Russian TU-144 and Franco-British Concorde versions. The SST would largely displace flights that currently serve business travel demand. The time saving enjoyed by SST patrons would have the greatest value to this traffic segment and there would probably be no net traffic generation effects as a result of SST flight activity, because this segment's demand for air travel is highly inelastic and relatively insensitive to service and fare levels in the aggregate. Tracing the influence of the SST traffic on the peak IAC calculations is difficult; specific schedules of the SST service would have to be proposed, and it is not clear from the proposed service configurations if the departure or arrival time will be the driving schedule component. The current generation of SSTs is quite noisy even when operating subsonically, and the imposition of curfews may impact the distribution of flight times, keeping their operations limited to daytime landmass overflights. We have assumed in our draft modeling effort that the SST contributes to the same business travel peak as the conventional jets it displaces. We consider a second generation SST in the forecast period

unlikely because of the long development lead time and the high cost ($3 to $5 billion*) of development.

<u>Base Scenario</u>--Our base case for aircraft technological development embodies the following assumptions:

- Introduction of fuel efficient aircraft (such as the B-7X7 and the DC-X-200) occurs at the latest by the 1985-90 time period.
- Operational fuel efficiency of 12-15% saving over the base is attained.
- No advanced technology aircraft generation occurs in the forecast period.
- There is limited use of the SST.

The unit operating cost saving assumptions in these scenarios are converted to rates of growth of the "fixed cost" factor in the forecasting model. The rates of growth are calculated to yield the percentage savings discussed in the scenario over the forecast period; that is, the saving is completely realized only at the end of the period.

The other major areas of uncertainty about the future operating environment concern the likely trends in the cost of fuel and labor. Discussions of these trends and those of other cost components follows.

<u>Fuel</u>--The IATA fuel monitoring program indicates that while international aviation fuel prices increased by 3-1/4 times from early 1973 to July 1974, the rates of growth in aviation fuel prices have stabilized, and in 1975 were "in line with general cost increases."† We do not

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* J. E. Gorham et al., "The Economic Impact of Energy Shortages on Commercial Air Transportation and Aviation Manufacture," Stanford Research Institute for FEA (1975).

† IATA, <u>The State of the Air Transport Industry</u> (1975), p. 3.

anticipate fuel price increases of the magnitude of 1973-74. We expect the trend in these prices to correspond roughly (in real terms) with average international price increases.* In our sensitivity analysis, however, optimistic and base scenarios of fuel prices are explored in which the real increases are 1% per annum above and below other international price index changes. There is a direct and separate treatment of fuel prices in the forecasting model.

Obviously, extreme scenarios of embargo or other severe restrictions on petroleum supplies would have severe negative influences on activity and IAC estimates. We believe that these conditions would have severe impacts on world economic development in general, but that they are unlikely or at least short-lived possibilities.

Labor--Increases in unit labor costs to the air carriers have been disguised considerably by the increases in productivity that jet aircraft have generated. As the rate of productivity increase slows (as the growth in average gauge slows), the labor components of operating cost will become more significant components of the average unit costs (such as on a ton-kilometer basis), and the average flight cost growth rate will approach more nearly that of its components. In all of the scenarios, labor cost is assumed to grow at a rate similar to overall international prices (i.e., zero real growth).

Other Cost Components--Interest and other financial expenses of the air carriers have typically represented only about 3% of airline costs, while airframe depreciation and landing and enroute charges together have

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*This in itself is a somewhat pessimistic assumption compared to historical trends. The cost of aviation fuel in early 1973 was the same in current dollars per gallon as it was during World War II (Source: ICAO Bulletin, July 1975, p. 16).

represented nearly 10%. We anticipate that expenses in both of these categories will increase in the future at a rate slightly above general price indices. In the case of the latter category, this is an anticipated consequence of increased attempts to recover facility costs through user charges.

In sum, the combined labor and other nonfuel cost components are expected to make total flight costs (for a given aircraft gauge) grow slightly more rapidly than the general price level. In the sensitivity analysis, this percentage (in real terms) is varied from 0.0 to 1.5% on a compounding per annum basis.

Our aircraft technology model described below permits incorporation of alternative assumptions concerning these parameters in several ways:

- The flight-cost relationship recognizes that the cost of a flight increases somewhat less than in proportion to the size or the stage length of the aircraft. If a new airframe design significantly altered these cost elasticities, they could be input directly in the model formulation.
- The flight cost model is parameterized directly for a fuel price index in real terms.
- The flight cost model is parameterized directly for a unit or fixed cost growth factor to represent (in real terms) the change in the overall labor and capital costs of operating a flight.

The translation of the technological and resource future of the air transportation industry into parametric assumptions then permits the model to select the likely rate of change in the gauge of the aircraft fleet, the average fare, and the flight frequency that would be observed in each market.

Appendix D: THE DYNAMIC AIRCRAFT SIZE DISTRIBUTION MODEL

The forecasting model used in this research projects the rate of increase in the average size of aircraft, using seat capacity as a rough proxy for size. Effectively, then, the mean of the distribution of aircraft sizes is known at all times. Therefore, it is possible to calculate the probability that an aircraft of a certain current size will become an aircraft of another (larger) size in the future once a form of the frequency distribution is assumed.

We assumed a Weibull distribution of aircraft sizes because of the need for a distribution of values which are nonnegative and because, in spite of its being similar to the normal in behavior, it is quite easy to parameterize on empirical data.

Data on the frequency of flights by aircraft of various sizes were drawn from a complete sample of the June 1975 OAG tape for all flights over 400 nautical miles. The estimated form of the cumulative Weibull was then obtained and found to be:

$$F(S) = 1 - e^{-\left(\frac{S}{a}\right)^{b}} ,$$

where

> $F(S)$ is the probability of an aircraft being smaller than Size S
>
> S is the size of the aircraft (proxied in seats)
>
> a,b are parameters of the function and equal to 232.2 and 2.295, respectively.

As the forecast average aircraft size changes, the parameter a is assumed to change. A new probability of an aircraft being a particular size is then obtained. The probability of an aircraft being in Class B (with the class defined by upper and lower size bounds b_1 and b_2, respectively) if it was previously a Class A aircraft (with upper and lower

bounds of a_1 and a_2, respectively) can then be easily calculated. The formula for this probability [abbreviated by P(B:A)] is

$$P(B:A) = \frac{F(b_1/r) - F(a_2)}{F(a_1) - F(a_2)} \quad ,$$

where r is the ratio of the forecast average aircraft size to the current aircraft size.

This formula is valid for all $r \geq 1$ and when $a_1 r \leq b_1$.

Appendix E: ASSUMED SST-ELIGIBLE AIRPORT CODES

1980

POTENTIAL SST ROUTE AIRPORT CODES
JFK, IAD, BOS, LHR, ORY, FRA, MAD, CPH, AMS,
ROM, DKR, RIO, BUE, SVO, LED, KHV

1985

JFK, IAD, BOS, LHR, ORY, FRA, MAD, CPH, AMS, ROM, DKR, RIO, BUE, MIA,
LIM, SCL, LAX, HNL, PPG, SYD, ANC, HND, HKG, SVO, LED, KHV, BHA, THR

1990

JFK, IAD, BOS, LHR, ORY, FRA, MAD, CPH, AMS, ROM, DKR, RIO, BUE, MIA,
LIM, SCL, LAX, HNL, PPG, SYD, ANC, HND, HKG, SVO, LED, KHV, PEK, BHA,
DAM, TVL, THR, JED, BOM

Appendix F: ASSUMED ALLOCATION OF GENERAL AVIATION TO AIRCRAFT TYPES, BY REGION

GENERAL AVIATION DISTRIBUTION BY FLIGHT ORIGIN REGION

	1	2	3	4	5	6	7	8	9	10
LER	.30	.30	.75	.27	.32	.32	0.00	.44	.31	.31
C50	.36	.36	.12	.64	.58	.58	.40	.33	.31	.31
GLF	.34	.34	.13	.09	.10	.10	.60	.23	.38	.38

Source: Flight International

Appendix G: THE METHODOLOGY FOR ISOLATING POTENTIAL OVERFLIGHTS OF THE USSR AND MAINLAND CHINA

The objective of this methodology was to determine those flights whose structure was such that it might be changed if it were permitted to overfly the Soviet Union or Mainland China. The approach used was for the computer to remove a list of current flights whose structure surely would not be changed.

The flights were obtained from the November 1974 tape version of the Official Airline Guide. Each record on this tape describes a part of a flight, called here a leg, between two successive cities on the route of the flight. The legs of a given flight number are in sequence by the three-letter codes of the departure and arrival airports of the legs rather than in sequence of stops (that is, the itinerary sequence).

The tape was processed in two passes by a program called FILTER. During the first pass, FILTER eliminated from the tape all flights which satisfied any of the following:

- The origin and destination airports of each leg of the flight were in a single, readily checked hemisphere. If a flight was currently contained within the western or southern hemispheres or the hemisphere between 18° east and 162° west longitude, it was eliminated from consideration.
- The legs could be arranged in a stop sequence and the great circle distance from each airport to the one after the next (if any) was less than 3000 miles.
- The origin and the destination airports of each leg of the flight were in one of nine hemispheres that approximately bound the land area of the combined Soviet Union and China. The nine hemispheres are determined by great circles.

The output of FILTER was entered into a disc file which contained the approximately 1547 flights which had passed through these first tests.

Examination of this file indicated that a number of other tests should be applied since the list contained flights which, by inspection, were not candidates for potential overflights or could not be stop sequences. The difficulty in determining the stop sequence of flights was traced to the occurrence in the file of legs showing "discontinue" and "effective" dates which interfered with the ordering of the legs. All flights which had an alternative nonzero discontinue date were eliminated.

The second pass through FILTER also applied the following tests:

- If the airline code was one belonging to a communist bloc nation (SU, LO, IF, LZ, MA, OK, AY, etc.) the flights were eliminated from the list.
- Flights of one leg only were eliminated.
- If the country of origin or destination of any leg of the flight was in a current overflight area, the flight was eliminated. This included European Russia, Poland, Czechoslavakia, Hungary, Bulgaria, Rumania, Siberia, China, Mongolia, North Korea, and the Soviet Kuril Islands.

The output of the second pass of FILTER contained 377 flights. It was feasible to review this list by manual means. The examination suggested that the main category of flights that might overfly if permitted is those that are currently routed through Anchorage. There are less than 100 of these. Since the total roster of flights was over 32,000, it was felt that modification of the model to simulate diversion to overflights was not warranted.

Appendix H

PROGRAM OUTPUT FOR JUNE 1975

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

AIRCRAFT LIST

CLASS	NAME	VARIANT1	PC	VARIANT2	PC
L10	L10	L10	100		-0
707	707	707	100		-0
727	727	727	100		-0
737	737	737	100		-0
747	747	747	100		-0
D10	D10	D10	100		-0
A38	A38	A38	100		-0
TRD	TRD	TRD	100		-0
F28	F28	F28	100		-0
T34	T34	T34	100		-0
T54	T54	T54	100		-0
Y62	Y62	Y62	100		-0
Y86	Y86	Y86	:00		-0
Y40	Y40	Y40	100		-0

GENERAL AVIATION DISTRIBUTION BY FLIGHT ORIGIN REGION

	1	2	3	4	5	6	7	8	9	10
LER	.30	.30	.75	.27	.32	.32	0.00	.44	.31	.31
C50	.36	.36	.12	.64	.58	.58	.40	.33	.31	.31
GLF	.34	.34	.13	.09	.10	.10	.60	.23	.38	.38

POTENTIAL SST ROUTE AIRPORT CODES

XXX

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE L10 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.78	.36	.71	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	2.40	9.93	7.89	.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	.29	.35	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.11	.00	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.22	2.82	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.36	1.01	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE L10 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.51	.75	.91	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	4.92	15.90	9.77	.02	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.19	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.16	.71	.35	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.14	.02	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.31	3.37	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.17	0.00	
180													

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AD-A039 016 STANFORD RESEARCH INST MENLO PARK CALIF F/G 1/2
FORECASTS OF AIRCRAFT ACTIVITY BY ALTITUDE, WORLD REGION,--ETC(U)
NOV 76 R. J. POZDENA
UNCLASSIFIED FAA-AVP-76-18 N/L

2 OF 2
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DATE
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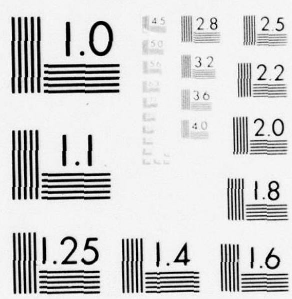

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE L10 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60/-50	-50/-40	-40/-30	-30/-20	-20/-10	-10/0	0/10	10/20	20/30	30/40	40/50	50/60
-180/-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140/-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.97	5.15	3.61
-100/-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.91	7.66	30.10	24.01	.49
-60/-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.28	0.00
-20/20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.17	1.65	.36
20/60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.52	.25	0.00
60/100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100/140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.34	3.93	0.00	0.00
140/180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	1.37	0.00

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE L10 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60/-50	-50/-40	-40/-30	-30/-20	-20/-10	-10/0	0/10	10/20	20/30	30/40	40/50	50/60
-180/-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140/-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.79	11.98	5.94
-100/-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	37.28	87.94	47.62	1.21
-60/-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.50	0.00
-20/20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.48	6.22	.40
20/60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	1.02	0.00
60/100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100/140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	7.01	0.00	0.00
140/180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.56	1.94	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE L10 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60/-50	-50/-40	-40/-30	-30/-20	-20/-10	-10/0	0/10	10/20	20/30	30/40	40/50	50/60
-180/-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140/-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.21	8.91	5.35
-100/-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.83	25.66	46.85	31.18	.61
-60/-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.19	0.00
-20/20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.36	3.05	.14
20/60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.47	.27	0.00
60/100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100/140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.96	3.52	0.00	0.00
140/180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71	.72	0.00

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE L10 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60/-50	-50/-40	-40/-30	-30/-20	-20/-10	-10/0	0/10	10/20	20/30	30/40	40/50	50/60
-180/-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140/-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.77	.67	.37
-100/-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	4.76	10.40	3.59	.02
-60/-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	0.00
-20/20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.07	.72	.02
20/60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.04	.02	0.00
60/100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100/140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.18	1.24	0.00	0.00
140/180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.98	.37	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707

ALTITUDE BANDS

	6000 / 8000	8000 / 9000	9000 / 10000	10000 / 11000	11000 / 12000	12000 / 13000	13000 / 14000	14000 / 15000	15000 / 16000	16000 / 17000	17000 / 18000	18000 / 19000
NORTH POLE	3.08	3.81	33.24	54.20	56.89	2.85	.74	0.00	0.00	0.00	0.00	0.00
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707 AT ALTITUDE 6000 -8000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	0.00	0.00	.74	0.00	0.00	.52	1.86	0.00	0.00	.24
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.06	.39	31.70	8.26	1.87
-100 / -60	0.00	.05	1.36	.06	1.88	1.01	3.16	7.95	10.95	27.10	47.18	.05
-60 / -20	0.00	0.00	1.69	1.92	.13	.61	0.00	.46	0.00	.45	.32	0.00
-20 / 20	0.00	0.00	.50	0.00	.01	1.46	3.45	1.87	.67	3.47	15.17	12.32
20 / 60	0.00	0.00	0.00	1.25	.73	1.20	.90	1.02	6.41	14.07	.78	.48
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	.17	1.95	3.07	.77	.20	0.00
100 / 140	0.00	0.00	.38	0.00	0.00	1.60	3.10	4.02	9.23	7.69	0.00	0.00
140 / 180	0.00	.18	2.30	.36	.52	0.00	0.00	0.00	0.00	.76	.66	0.00

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707 AT ALTITUDE 8000 -9000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	.01	.29	1.56	0.00	0.00	.52	1.86	0.00	0.00	.31
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.07	1.17	63.49	24.13	3.78
-100 / -60	0.00	.05	3.11	.49	2.29	2.03	5.33	12.51	20.98	57.49	88.58	.18
-60 / -20	0.00	0.00	1.85	2.28	.60	.73	0.00	.46	0.00	.56	.58	0.00
-20 / 20	0.00	0.00	.50	0.00	.35	2.04	4.99	3.04	1.48	5.85	33.33	14.19
20 / 60	0.00	0.00	.87	2.60	1.55	1.52	1.90	2.25	11.53	27.84	4.63	.60
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	.60	3.44	8.44	.86	.20	0.00
100 / 140	0.00	0.00	.75	.15	.14	3.52	5.34	7.92	16.13	15.14	.26	0.00
140 / 180	0.00	.21	3.33	1.42	.52	0.00	0.00	0.00	0.00	1.29	.75	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707 AT ALTITUDE 9000-10000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	.85	1.81	2.43	2.65	1.92	3.56	16.79	4.64	7.26	5.27
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	.45	1.14	7.61	120.06	45.07	10.52
-100 / -60	0.00	.05	5.00	4.06	6.48	10.98	14.80	22.58	35.11	104.74	188.79	12.05
-60 / -20	0.00	0.00	3.23	6.33	9.64	8.26	6.83	6.96	8.59	10.24	36.89	97.58
-20 / 20	0.00	0.00	.43	.15	2.54	4.02	10.32	14.19	17.23	24.86	71.78	65.59
20 / 60	0.00	0.00	1.80	3.00	1.79	2.67	6.94	6.69	23.75	48.15	16.63	3.34
60 / 100	0.00	0.00	.27	.77	0.00	0.00	1.72	6.56	18.56	3.68	.75	.98
100 / 140	0.00	0.00	.98	6.67	9.26	9.62	9.90	15.02	22.84	22.01	3.16	2.13
140 / 180	0.00	.29	6.79	4.94	1.05	.46	.70	2.28	1.97	7.19	11.70	6.11

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707 AT ALTITUDE 10000-11000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	1.38	3.26	4.97	4.25	3.09	5.28	25.44	7.47	11.68	10.78
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	.73	1.95	19.78	245.61	89.36	25.35
-100 / -60	0.00	.04	5.96	10.14	11.28	22.42	25.00	45.40	87.52	227.39	294.61	19.44
-60 / -20	0.00	0.00	5.68	11.57	17.52	13.30	10.99	10.86	13.81	16.29	58.93	156.37
-20 / 20	0.00	0.00	.30	.25	4.89	5.79	15.76	21.97	28.47	44.56	127.79	103.15
20 / 60	0.00	0.00	2.20	4.24	4.73	6.06	12.99	10.79	45.41	92.74	34.04	6.43
60 / 100	0.00	0.00	.44	1.25	0.00	0.00	4.04	12.92	32.85	6.02	1.04	1.57
100 / 140	0.00	0.00	1.75	10.91	15.06	13.02	17.24	40.29	44.55	38.75	4.88	3.41
140 / 180	0.00	.68	15.81	10.52	1.35	.75	1.12	3.67	3.17	10.50	18.22	[illegible]

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	1.53	4.32	6.72	4.61	3.34	5.49	26.70	8.08	12.62	10.29	
-140	0.00	0.00	0.00	0.00	0.00	0.00	.79	1.97	16.25	245.86	105.08	20.43	
-100	0.00	.02	3.54	8.85	9.69	19.03	23.61	42.82	74.56	185.22	291.48	21.27	
-60	0.00	0.00	4.15	9.41	17.72	14.05	11.58	11.59	14.93	17.14	63.18	169.70	
-20	0.00	0.00	.13	.27	5.82	4.82	12.62	22.70	31.14	47.03	113.29	100.04	
20	0.00	0.00	1.19	4.76	5.57	4.56	11.54	10.05	34.94	84.65	41.98	5.73	
60	0.00	0.00	.47	1.35	0.00	0.00	4.56	15.23	30.63	5.67	1.04	1.70	
100	0.00	0.00	2.78	12.22	16.66	11.55	13.81	28.11	35.34	29.07	4.91	3.71	
140	0.00	.40	13.36	12.47	1.30	.81	1.21	3.96	3.43	10.31	19.33	10.62	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.04	.89	2.76	0.00	0.00	0.00	0.00	0.00	0.00	1.17	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.07	3.61	90.50	41.61	6.07	
-100	0.00	0.00	1.52	1.85	1.43	2.91	4.86	14.89	31.86	74.78	80.04	.35	
-60	0.00	0.00	.87	1.41	1.44	.45	0.00	.08	0.00	.17	.22	0.00	
-20	0.00	0.00	.04	0.00	1.13	.99	2.61	2.17	2.22	6.12	35.75	4.91	
20	0.00	0.00	.60	2.69	2.85	1.49	2.22	2.04	10.99	33.18	12.01	.50	
60	0.00	0.00	0.00	0.00	0.00	0.00	1.50	5.25	10.22	.38	0.00	0.00	
100	0.00	0.00	1.21	.48	.43	1.88	4.47	11.72	16.38	13.89	.18	0.00	
140	0.00	.16	4.32	3.58	.14	0.00	0.00	0.00	0.00	.36	.12	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 707 AT ALTITUDE 13000-14000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.02	.40	1.08	0.00	0.00	0.00	0.00	0.00	0.00	.11	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.19	25.00	14.16	.76	
-100	0.00	0.00	.07	.18	.10	.02	1.04	3.71	6.51	13.40	22.17	.15	
-60	0.00	0.00	.01	.01	.22	.12	0.00	.02	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	.42	.14	.22	.58	.75	.28	7.31	.92	
20	0.00	0.00	0.00	.89	.95	.16	.28	.40	1.19	7.90	4.44	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	.48	1.86	2.39	0.00	0.00	0.00	
100	0.00	0.00	.53	.21	.19	.25	.68	1.02	3.14	2.38	0.00	0.00	
140	0.00	0.00	.76	1.25	.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 727

	A L T I T U D E B A N D S												
	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	2.31	3.61	6.14	7.89	1.39	.04	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 727 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.64	0.00	0.00	0.00	.19	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	47.87	19.86	3.51	
-100	.20	.07	.48	.08	1.21	.36	1.11	4.12	32.86	109.90	93.67	.21	
-60	0.00	0.00	.50	3.37	1.78	1.30	0.00	.10	.00	0.00	0.00	0.00	
-20	0.00	0.00	.65	.28	0.00	.10	.37	.39	.66	7.11	17.28	5.97	
20	0.00	0.00	.57	1.31	.10	0.00	0.00	0.00	.37	3.54	1.77	.54	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.17	.50	.20	.10	0.00	
100	0.00	0.00	2.80	.66	.63	0.00	.23	.94	1.93	4.34	.27	0.00	
140	0.00	0.00	2.10	1.12	.18	.12	.06	.41	0.00	.06	.81	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 727 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.64	0.00	-0.00	0.00	1.27	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.41	103.50	47.35	8.06	
-100	.20	.56	.66	.62	1.49	.99	1.87	5.09	47.87	252.54	158.65	.31	
-60	0.00	0.00	.77	4.90	4.68	2.07	0.00	.12	.05	0.00	0.00	0.00	
-20	0.00	0.00	.63	.41	0.00	.12	.47	.56	.77	11.17	41.72	7.76	
20	0.00	0.00	1.81	1.80	.10	0.00	0.00	0.00	.48	6.20	3.75	1.22	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.32	1.06	.42	.10	0.00	
100	0.00	0.00	6.46	1.05	1.40	0.00	.56	1.78	3.25	8.02	1.02	0.00	
140	0.00	0.00	4.72	1.98	.62	.11	.06	.41	0.00	.34	.79	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 727 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.64	0.00	0.00	0.00	3.36	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.31	216.15	104.28	17.78	
-100	.18	1.46	.98	1.63	2.00	2.26	3.45	6.74	75.97	542.58	297.65	.59	
-60	0.00	0.00	1.34	8.14	10.64	3.59	0.00	.15	.17	0.00	0.00	0.00	
-20	0.00	0.00	.54	.70	.10	.16	.68	1.47	1.48	19.69	93.27	11.24	
20	0.00	0.00	4.66	2.83	.08	0.00	0.00	0.00	.66	11.70	7.46	2.44	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.58	2.18	.92	.08	0.00	
100	0.00	0.00	13.34	1.83	3.13	0.00	1.33	3.27	5.97	16.16	2.76	0.00	
140	0.00	0.00	10.66	3.54	1.42	.10	.06	.41	0.00	.99	.67	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 727 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.45	0.00	0.00	0.00	5.19	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.35	321.59	150.27	26.22	
-100	.13	3.31	1.59	3.39	1.75	3.43	3.57	7.49	101.33	759.56	301.38	.93	
-60	0.00	0.00	1.91	8.08	14.96	4.47	0.00	.14	.27	0.00	0.00	0.00	
-20	0.00	0.00	.27	.50	.10	.11	.50	1.21	1.47	23.19	113.45	10.44	
20	0.00	0.00	3.69	1.97	.04	0.00	0.00	0.00	.99	13.44	13.22	4.32	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	3.13	.82	.04	0.00	
100	0.00	0.00	25.54	2.12	2.63	0.00	1.03	6.25	6.45	13.84	2.20	0.00	
140	0.00	0.00	9.37	6.02	3.07	.08	.04	.29	0.00	.80	.33	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 727 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.27	0.00	0.00	0.00	.93	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.17	51.28	23.82	5.07	
-100	.02	.57	.28	.59	.31	.61	.66	1.29	17.41	134.06	52.45	.24	
-60	0.00	0.00	.41	1.66	2.76	.79	0.00	.01	.01	0.00	0.00	0.00	
-20	0.00	0.00	.05	.10	.14	.04	.15	.90	.80	4.65	20.84	1.39	
20	0.00	0.00	.74	.38	.01	0.00	0.00	0.00	.17	2.44	2.30	.45	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.19	.56	.16	.01	0.02	
100	0.00	0.00	4.05	.38	.51	0.00	.21	1.09	1.18	2.66	.44	0.00	
140	0.00	0.00	1.66	1.04	.53	.01	.02	.17	0.00	.16	.06	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 727 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.03	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.06	1.50	.71	.13	
-100	.00	.01	.01	.02	.01	.02	.02	.04	.52	4.23	1.88	.00	
-60	0.00	0.00	.01	.05	.09	.03	0.00	.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	.00	.00	0.00	.00	.00	.01	.00	.13	.71	.07	
20	0.00	0.00	.03	.02	.00	0.00	0.00	0.00	.00	.08	.06	.02	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.02	.01	.00	0.00	
100	0.00	0.00	.10	.01	.02	0.00	.01	.03	.04	.11	.02	0.00	
140	0.00	0.00	.07	.03	.01	.00	0.00	0.00	0.00	.01	.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 737

	ALTITUDE BANDS											
	6000 8000	8000 9000	9000 10000	10000 11000	11000 12000	12000 13000	13000 14000	14000 15000	15000 16000	16000 17000	17000 18000	18000 19..
NORTH POLE	5.85	11.43	12.28	7.79	.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 737 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	LATITUDE BANDS											
	-60 -50	-50 -40	-40 -30	-30 -20	-20 -10	-10 0	0 10	10 20	20 30	30 40	40 50	50 60
-180 -140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140 -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.11	3.58	16.40	10.31	10.51
-100 -60	0.00	.49	1.10	.48	.15	.18	.10	1.97	13.10	49.54	33.82	.47
-60 -20	0.00	0.00	1.39	4.23	3.28	1.14	.05	0.00	0.00	0.00	.34	0.00
-20 20	0.00	0.00	.10	0.00	0.00	.53	.77	.24	.91	5.24	31.21	20.61
20 60	0.00	0.00	.29	.29	.08	.52	.35	.78	1.88	1.37	1.83	1.45
60 100	0.00	0.00	0.00	0.00	0.00	.25	.38	1.28	2.33	0.00	.07	0.00
100 140	0.00	0.00	.17	0.00	0.00	4.13	2.86	.36	.05	3.26	0.00	0.00
140 180	0.00	.53	1.77	2.23	.35	.20	0.00	0.00	0.00	.18	.19	0.00

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 737 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	LATITUDE BANDS											
	-60 -50	-50 -40	-40 -30	-30 -20	-20 -10	-10 0	0 10	10 20	20 30	30 40	40 50	50 60
-180 -140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140 -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.15	10.30	36.51	20.26	18.84
-100 -60	0.00	1.21	4.04	1.17	.69	.33	.10	2.08	25.70	150.68	64.01	1.40
-60 -20	0.00	0.00	1.98	8.07	9.26	3.05	.05	0.00	0.00	0.00	.81	0.00
-20 20	0.00	0.00	.10	0.00	0.00	1.22	1.52	.71	.89	15.46	91.35	47.53
20 60	0.00	0.00	.79	.52	.23	1.12	.35	1.85	3.38	2.59	5.31	4.39
60 100	0.00	0.00	0.00	0.00	0.00	.25	.37	2.46	7.35	0.00	.07	0.00
100 140	0.00	0.00	.17	0.00	0.00	11.33	6.53	.94	.05	7.37	0.00	0.00
140 180	0.00	1.19	5.61	4.78	.33	.20	0.00	0.00	0.00	.61	.38	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 737 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	LATITUDE BANDS											
	-60 -50	-50 -40	-40 -30	-30 -20	-20 -10	-10 0	0 10	10 20	20 30	30 40	40 50	50 60
-180 -140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140 -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.14	12.76	43.35	22.96	20.07
-100 -60	0.00	1.49	5.39	1.44	1.00	.41	.10	1.62	29.00	187.93	71.03	1.43
-60 -20	0.00	0.00	1.92	9.10	11.39	3.57	.05	.05	0.00	0.00	.92	0.00
-20 20	0.00	0.00	.07	0.00	0.00	1.47	1.78	.84	.69	18.46	114.46	56.76
20 60	0.00	0.00	.99	.57	.30	1.33	.32	2.27	3.78	3.12	6.53	5.44
60 100	0.00	0.00	0.00	0.00	0.00	.23	.51	2.71	9.19	0.00	.07	0.00
100 140	0.00	0.00	.12	0.00	0.00	14.29	7.65	1.10	.04	8.81	0.00	0.00
140 180	0.00	1.42	7.28	5.62	.24	.20	0.00	0.00	0.00	.80	.44	0.00

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 737 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	LATITUDE BANDS											
	-60 -50	-50 -40	-40 -30	-30 -20	-20 -10	-10 0	0 10	10 20	20 30	30 40	40 50	50 60
-180 -140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140 -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	10.85	29.57	16.20	17.50
-100 -60	0.00	1.01	3.81	.98	.73	.28	.07	1.03	23.31	165.40	53.86	1.20
-60 -20	0.00	0.00	1.44	6.43	10.47	3.95	.04	.05	0.00	0.00	1.02	0.00
-20 20	0.00	0.00	.03	0.00	0.00	1.00	1.38	.97	.42	20.47	92.01	40.74
20 60	0.00	0.00	.68	.36	.21	.88	.21	1.56	2.45	2.50	6.17	4.91
60 100	0.00	0.00	0.00	0.00	0.00	.16	.36	2.29	8.44	0.00	.05	0.00
100 140	0.00	0.00	.05	0.00	0.00	9.82	6.57	1.16	.02	5.88	0.00	0.00
140 180	0.00	.95	5.07	3.72	.10	.14	0.00	0.00	0.00	.56	.29	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 737 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50 60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.13	.05	.08	.32
-100	0.00	0.00	.02	.02	.07	.07	.04	.04	.59	2.24	.60	.02
-60	0.00	0.00	.04	.13	.31	.10	.02	.07	0.00	0.00	.03	0.00
-20	0.00	0.00	0.00	0.00	0.00	.02	.12	.02	.01	.49	.85	.18
20	0.00	0.00	0.00	0.00	0.00	0.00	.10	.05	.08	.42	.16	.07
60	0.00	0.00	0.00	0.00	0.00	.06	.35	.04	.13	0.00	.03	0.00
100	0.00	0.00	0.00	0.00	0.00	.04	.16	.03	.00	0.00	0.00	0.00
140-	0.00	0.00	0.00	0.00	0.00	.08	0.00	0.00	0.00	0.00	0.00	0.00
180												

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747

	ALTITUDE BANDS												
	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	1.43	1.43	32.92	32.52	46.20	.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180 / -140	0.00	0.00	0.00	0.00	.12	0.00	0.00	.75	4.42	0.00	0.00	0.00	
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.27	1.72	0.00	
-100 / -60	0.00	0.00	0.00	0.00	0.00	0.00	.15	1.34	1.23	2.46	12.87	0.00	
-60 / -20	0.00	0.00	0.00	.36	0.00	0.00	.18	.39	0.00	0.00	0.00	0.00	
-20 / 20	0.00	0.00	0.00	.22	.00	.15	0.00	.10	0.00	.57	4.19	6.60	
20 / 60	0.00	0.00	0.00	.68	.15	.30	0.00	0.00	.62	1.84	.21	0.00	
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.86	.68	.00	0.00	0.00	
100 / 140	0.00	0.00	.22	0.00	0.00	0.00	.88	1.46	2.17	5.70	0.00	0.00	
140 / 180	0.00	0.00	1.06	0.00	.23	0.00	0.00	0.00	0.00	2.00	.89	0.00	

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180 / -140	0.00	0.00	0.00	0.00	.12	0.00	0.00	2.30	4.66	0.00	0.00	0.00	
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.79	1.73	0.00	
-100 / -60	0.00	0.00	0.00	0.00	0.00	0.00	.15	1.31	1.83	3.39	12.58	0.00	
-60 / -20	0.00	0.00	0.00	.36	0.00	0.00	.14	.36	0.00	0.00	0.00	0.00	
-20 / 20	0.00	0.00	0.00	.21	.08	.15	0.00	.10	0.00	.55	4.25	6.50	
20 / 60	0.00	0.00	0.00	.63	.20	.30	0.00	0.00	.62	1.99	.28	0.00	
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.85	.65	.07	0.00	0.00	
100 / 140	0.00	0.00	.31	0.00	0.00	0.00	.85	1.79	2.41	5.52	0.00	0.00	
140 / 180	0.00	0.00	1.37	0.00	.23	0.00	0.00	0.00	0.00	1.81	.80	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180 / -140	0.00	0.00	0.00	0.00	1.03	1.55	1.49	4.18	50.66	5.01	10.08	10.47	
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.03	53.59	17.79	8.99	
-100 / -60	0.00	0.00	0.00	0.00	0.00	.14	.82	1.51	5.19	11.26	82.53	8.29	
-60 / -20	0.00	0.00	0.00	.36	3.21	2.98	2.61	3.44	3.59	3.30	39.59	109.15	
-20 / 20	0.00	0.00	0.00	.25	1.24	1.99	2.09	1.61	4.44	5.66	32.25	64.74	
20 / 60	0.00	0.00	0.00	1.33	.77	.40	.88	.93	3.50	10.91	5.50	0.00	
60 / 100	0.00	0.00	0.00	0.00	.29	.49	.97	4.34	8.23	.26	0.00	0.00	
100 / 140	0.00	0.00	.56	4.10	5.03	4.64	2.56	2.72	5.22	8.09	.39	0.00	
140 / 180	0.00	0.00	2.84	2.82	.39	0.00	0.00	0.00	3.27	27.87	23.29	11.59	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	1.37	2.24	2.16	20.44	71.26	7.25	14.60	15.30	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38	79.78	28.43	13.22	
-100	0.00	0.00	0.00	0.00	0.00	.21	1.03	1.13	13.19	24.97	111.39	12.01	
-60	0.00	0.00	0.00	.15	4.65	4.31	3.58	4.57	5.20	4.78	57.33	158.07	
-20	0.00	0.00	0.00	.12	2.51	2.75	3.02	2.23	6.43	7.61	46.40	86.90	
20	0.00	0.00	0.00	1.76	2.54	.80	1.27	1.34	5.13	18.30	8.99	0.00	
60	0.00	0.00	0.00	0.00	.42	.71	1.41	7.26	13.45	.98	0.00	0.00	
100	0.00	0.00	1.99	5.94	7.28	6.72	3.43	6.74	11.58	11.25	.56	0.00	
140	0.00	0.00	6.51	4.92	.38	0.00	0.00	0.00	4.73	38.22	32.72	16.76	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 747 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.54	1.08	0.00	0.00	.04	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.20	3.62	1.58	.06	
-100	0.00	0.00	0.00	0.00	0.00	0.00	.00	.21	3.16	5.11	2.68	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	.05	.05	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	.02	.31	.01	0.00	0.00	0.00	.05	1.89	.15	
20	0.00	0.00	0.00	.36	.56	.18	0.00	0.00	.23	1.95	.48	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.60	.89	.26	0.00	0.00	
100	0.00	0.00	.54	0.00	0.00	0.00	.45	2.10	2.55	3.01	0.00	0.00	
140	0.00	0.00	1.50	.25	.03	0.00	0.00	0.00	0.00	.32	.11	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 010

	ALTITUDE BANDS 6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	1.33	1.32	20.58	20.32	28.49	.04	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 010 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	.24	0.00	0.00	0.00	2.28	0.00	0.00	.05	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.08	15.37	5.22	.15	
-100	0.00	0.00	0.00	0.00	0.00	0.00	.14	.97	4.87	3.57	17.55	0.00	
-60	0.00	0.00	.05	0.00	.06	0.00	.05	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	.15	.67	0.00	0.00	.76	.61	.00	.28	3.04	1.52	
20	0.00	0.00	0.00	0.00	.00	.72	0.00	0.00	.00	.77	.02	.08	
60	0.00	0.00	0.00	.26	.11	.07	0.00	.57	.74	.13	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	.14	.46	1.39	.72	.70	0.00	0.00	
140	0.00	.14	1.07	.11	.35	0.00	0.00	0.00	0.00	.39	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 010 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	.24	0.00	0.00	0.00	2.28	0.00	0.00	.27	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.43	21.25	8.29	.80	
-100	0.00	0.00	.05	0.00	.06	0.00	.23	1.08	5.94	6.03	23.59	0.00	
-60	0.00	0.00	.15	.77	0.00	0.00	.06	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	.03	.82	1.04	.62	.02	.30	4.00	1.59	
20	0.00	0.00	0.00	.29	.18	.13	0.00	0.00	.01	.92	.10	.12	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.61	.83	.22	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	.20	.56	1.96	.93	.82	0.00	0.00	
140	0.00	.24	1.49	.37	.35	0.00	0.00	0.00	0.00	.39	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE 010 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.50	.78	1.44	2.64	1.15	1.15	27.02	3.47	0.00	2.28	
-140	0.00	0.00	0.00	0.00	0.00	.11	1.61	1.61	6.23	71.20	30.04	1.71	
-100	0.00	0.00	.05	0.00	.06	.49	.77	3.13	12.21	21.73	64.16	2.24	
-60	0.00	0.00	.39	2.17	4.77	4.72	4.73	3.23	4.95	6.61	9.89	10.43	
-20	0.00	0.00	0.00	0.00	.44	1.21	2.70	5.36	6.14	9.10	12.29	10.80	
20	0.00	0.00	0.00	.74	1.00	.17	.44	.49	1.51	8.55	4.43	.18	
60	0.00	0.00	0.00	0.00	0.00	0.00	.98	5.58	8.18	2.06	0.00	0.00	
100	0.00	0.00	0.00	1.85	2.83	2.94	1.19	4.30	2.28	4.12	0.00	0.00	
140	0.00	.29	2.33	1.57	1.23	0.00	0.00	.08	4.35	7.57	5.35	6.03	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE D10 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180 / -140	0.00	0.00	.50	.78	1.37	2.64	1.15	1.15	26.36	3.47	0.00	4.54	
-140 / -100	0.00	0.00	0.00	0.00	0.00	.11	1.61	1.61	9.78	157.15	83.32	8.42	
-100 / -60	0.00	0.00	.04	0.00	.04	.49	1.31	4.06	22.20	47.08	132.10	2.24	
-60 / -20	0.00	0.00	.35	2.41	4.77	4.72	4.79	3.23	4.95	6.61	9.89	10.43	
-20 / 20	0.00	0.00	0.00	0.00	1.66	2.95	4.68	5.60	6.88	9.79	19.26	11.22	
20 / 60	0.00	0.00	0.00	2.25	3.85	.85	.44	.49	1.92	12.72	7.34	.32	
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	.98	7.40	9.76	2.74	0.00	0.00	
100 / 140	0.00	0.00	0.00	1.85	2.83	3.15	1.50	9.50	7.48	7.68	0.00	0.00	
140 / 180	0.00	1.21	6.55	4.23	1.19	0.00	0.00	.08	4.35	7.46	5.35	6.03	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE D10 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180 / -140	0.00	0.00	.73	1.14	1.84	3.82	1.66	1.66	36.78	5.03	0.00	4.93	
-140 / -100	0.00	0.00	0.00	0.00	0.00	.17	2.33	2.33	11.59	106.09	48.01	7.55	
-100 / -60	0.00	0.00	.02	0.00	.03	.71	1.13	4.29	16.86	39.01	71.90	3.25	
-60 / -20	0.00	0.00	.41	2.32	6.91	6.84	6.85	4.68	7.03	9.58	14.32	15.10	
-20 / 20	0.00	0.00	0.00	0.00	.50	1.39	4.16	7.09	8.81	12.83	16.22	14.74	
20 / 60	0.00	0.00	0.00	.59	1.04	.69	.64	.71	2.14	11.70	6.28	.13	
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	1.41	7.26	11.13	3.24	0.00	0.00	
100 / 140	0.00	0.00	0.00	2.68	4.10	4.03	1.13	8.23	2.54	5.29	0.00	0.00	
140 / 180	0.00	.93	5.54	4.16	1.45	0.00	0.00	.11	6.30	10.56	7.74	8.74	

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE D10 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180 / -140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.41	
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.65	10.55	5.34	1.22	
-100 / -60	0.00	0.00	0.00	0.00	0.00	0.00	.16	.26	2.21	4.50	10.33	0.00	
-60 / -20	0.00	0.00	0.00	.17	0.00	0.00	.02	0.00	0.00	0.00	0.00	0.00	
-20 / 20	0.00	0.00	0.00	0.00	.03	.18	.52	.04	.02	.03	1.68	.16	
20 / 60	0.00	0.00	0.00	.05	.09	.13	0.00	0.00	.01	.25	.12	.06	
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.06	.15	.16	0.00	0.00	
100 / 140	0.00	0.00	0.00	0.00	0.00	.10	.17	1.11	.37	.20	0.00	0.00	
140 / 180	0.00	.19	.85	.49	.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE A38 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.57	.86	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.20	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	.11	0.00	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE A38 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.68	1.40	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.27	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.24	.13	0.00	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE A38 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.82	2.14	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.34	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.29	.14	0.00	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE A38 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.22	4.82	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.69	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	.39	0.00	0.00	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 UATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE A38 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.46	2.27	0.00	
20													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.35	0.00	0.00	
60													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
100													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16	.29	0.00	0.00	0.00	
140													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE A38 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.23	.94	0.00	
20													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.12	0.00	0.00	
60													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
100													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.22	.05	0.00	0.00	0.00	
140													
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE TRD

ALTITUDE BANDS	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	.06	.06	.06	.04	.01	.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE TRD AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS -180 \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.44	4.71	6.69	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.48	.33	.14	
100	0.00	0.00	0.00	0.00	0.00	0.00	.08	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	.05	0.00	0.00	0.00	0.00	0.00	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE TRD AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS -180 \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.47	13.32	9.81	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.72	.67	.26	
100	0.00	0.00	0.00	0.00	0.00	0.00	.29	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	.05	0.00	0.00	0.00	0.00	0.00	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE TRD AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS -180 \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.49	32.07	15.41	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	1.31	.46	
100	0.00	0.00	0.00	0.00	0.00	0.00	.66	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	.05	0.00	0.00	0.00	0.00	0.00	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE TRD AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS -180 \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.49	35.29	14.03	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	2.16	.88	
100	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	.03	0.00	0.00	0.00	0.00	0.00	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE TRD AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60 to -50	-50 to -40	-40 to -30	-30 to -20	-20 to -10	-10 to 0	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60
-180 to -140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140 to -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100 to -60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-60 to -20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-20 to 20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.08	6.61	2.53
20 to 60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.24	.38	.15
60 to 100	0.00	0.00	0.00	0.00	0.00	0.00	.25	0.00	0.00	0.00	0.00	0.00
100 to 140	0.00	0.00	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	0.00	0.00
140 to 180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE TRD AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60 to -50	-50 to -40	-40 to -30	-30 to -20	-20 to -10	-10 to 0	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60
-180 to -140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-140 to -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100 to -60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-60 to -20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-20 to 20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.24	.10
20 to 60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.01	.00
60 to 100	0.00	0.00	0.00	0.00	0.00	0.00	.01	0.00	0.00	0.00	0.00	0.00
100 to 140	0.00	0.00	0.00	0.00	0.00	0.00	.00	0.00	0.00	0.00	0.00	0.00
140 to 180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTICN (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE F28

ALTITUDE BANDS	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	2.47	2.87	2.56	1.66	.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE F28 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	.06	0.00	0.00	.05	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	.11	.59	.24	1.18	1.11	0.00	1.67	.83	.59	1.43	.60	
-60	0.00	0.00	.70	.82	.60	.36	.16	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	.15	.67	.11	.15	3.06	7.88	2.63	
20	0.00	0.00	0.00	.07	.36	.30	0.00	.12	.25	.48	.62	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	1.61	0.00	0.00	0.00	
100	0.00	0.00	.75	.91	.67	2.81	.35	.36	.25	0.00	0.00	0.00	
140	0.00	0.00	0.00	.23	.02	.35	.27	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE F28 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	.19	0.00	0.00	.05	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	.19	2.14	.47	2.07	2.71	0.00	4.96	3.24	1.29	2.59	1.36	
-60	0.00	0.00	.68	1.41	1.95	.93	.47	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	.15	1.05	.19	.15	6.49	24.93	6.87	
20	0.00	0.00	0.00	.19	1.21	1.31	0.00	.12	.52	2.39	1.56	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.47	5.35	0.00	0.00	0.00	
100	0.00	0.00	.73	4.61	.88	6.56	.69	1.57	.48	0.00	0.00	0.00	
140	0.00	0.00	0.00	.54	.51	.93	.76	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE F28 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	.21	0.00	0.00	.10	.20	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	.20	2.87	.53	2.27	3.31	0.00	6.01	4.06	1.52	2.87	1.52	
-60	0.00	0.00	.52	1.73	2.69	1.16	.59	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	.05	.15	1.25	.85	.82	7.90	31.13	8.15	
20	0.00	0.00	0.00	.23	1.44	1.59	0.00	.12	.84	3.24	1.87	0.00	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.76	7.00	0.00	0.00	0.00	
100	0.00	0.00	.55	5.88	.84	7.92	.72	1.97	.61	0.00	0.00	0.00	
140	0.00	0.00	0.00	.66	.67	1.10	.96	0.00	.44	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE F28 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	0.00	0.00	.30	0.00	0.00	.08	.20	0.00	0.00	0.00
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100 / -60	0.00	.12	2.04	.35	1.44	2.24	0.00	6.20	4.70	1.01	1.83	1.09
-60 / -20	0.00	0.00	.25	1.16	1.92	.79	.41	0.00	0.00	0.00	0.00	0.00
-20 / 20	0.00	0.00	0.00	0.00	.05	.11	.87	.80	.80	7.37	29.22	6.95
20 / 60	0.00	0.00	0.00	.16	1.91	2.37	0.00	.09	.63	4.72	1.59	0.00
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	4.89	0.00	0.00	0.00
100 / 140	0.00	0.00	.30	7.29	.52	5.32	.90	2.39	.43	0.00	0.00	0.00
140 / 180	0.00	0.00	0.00	.45	1.08	1.20	.66	0.00	.44	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE F28 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	0.00	0.00	.01	0.00	0.00	.09	.28	0.00	0.00	0.00
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100 / -60	0.00	0.00	.04	0.00	0.00	0.00	0.00	.13	.12	0.00	0.00	0.00
-60 / -20	0.00	0.00	.04	.28	.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-20 / 20	0.00	0.00	0.00	0.00	.07	.06	.23	.92	.99	1.00	.57	.08
20 / 60	0.00	0.00	0.00	0.00	.06	.08	0.00	.05	.35	.58	.02	0.00
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100 / 140	0.00	0.00	.01	.19	.01	0.00	.03	.06	.09	0.00	0.00	0.00
140 / 180	0.00	0.00	0.00	.00	.04	.03	0.00	0.00	.64	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T34

	A L T I T U D E B A N D S												
	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	.12	.12	.08	.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T34 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S												
	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	3.97	4.28	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.48	13.20	17.26	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	.24	1.09	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.31	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T34 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S												
	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	10.99	10.61	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.72	38.29	52.16	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	.91	4.32	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.35	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T34 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	L A T I T U D E B A N D S												
	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.04	13.57	12.90	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27	47.09	64.01	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.03	1.09	5.31	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.29	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T34 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.02	11.04	9.57	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	43.01	62.59	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	1.60	6.94	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.18	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T34 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.11	.06	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.68	1.17	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	.20	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T54

ALTITUDE BANDS	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	0.00	0.00	.24	.24	.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T54 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	.55	0.00	.05	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.05	.05	.01	.23	1.92	2.11	
20	0.00	0.00	0.00	0.00	0.00	0.00	.06	.16	.09	1.36	14.17	14.34	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.20	.00	.56	1.49	1.21	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	.24	.22	.18	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T54 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.07	1.04	0.00	.05	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.10	.38	.46	.49	4.24	3.70	
20	0.00	0.00	0.00	0.00	0.00	0.00	.14	.26	.36	3.16	36.72	34.99	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.51	.32	.82	4.57	1.36	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.30	.51	.54	.39	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T54 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS \ LATITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.09	2.05	0.00	.05	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.21	1.17	1.57	1.03	9.12	7.06	
20	0.00	0.00	0.00	0.00	0.00	0.00	.29	.42	.86	6.97	84.59	77.92	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	1.07	1.38	10.83	2.99	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.63	1.00	1.26	.76	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T54 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.13	2.31	0.00	.04	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.04	
20	0.00	0.00	0.00	0.00	0.00	0.00	.30	1.62	2.51	1.78	11.09	7.34	
60	0.00	0.00	0.00	0.00	0.00	0.00	.59	.75	1.88	10.92	111.49	111.82	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.24	1.70	1.40	20.00	3.32	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	1.97	.99	1.50	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T54 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.02	.42	0.00	.02	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.02	
20	0.00	0.00	0.00	0.00	0.00	0.00	.01	.08	.12	.22	2.02	1.35	
60	0.00	0.00	0.00	0.00	0.00	0.00	.10	.13	.32	1.49	18.34	20.03	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.38	.08	.19	2.68	2.40	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.22	.34	.20	.27	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE T54 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180													
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.01	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.07	.05	
60	0.00	0.00	0.00	0.00	0.00	0.00	.00	.00	.01	.04	.59	.59	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	0.00	.01	.06	.01	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.01	.01	.01	
180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62

ALTITUDE BANDS

	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	0.00	0.00	3.28	5.27	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62 AT ALTITUDE 6000 -8000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	.07	.20	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.21	.15	0.00	.05	.45	1.32	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.16	.11	2.80	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	0.00	.74	.21	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.11	.31	.20	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62 AT ALTITUDE 8000 -9000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.05	.07	.20	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.25	.35	0.00	.05	.90	2.24	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.32	1.10	4.90	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	0.00	1.43	.42	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.29	.46	.20	.47	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62 AT ALTITUDE 9000-10000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.36	.30	1.98	.35	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06	.66	3.90	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.42	.57	.27	.52	1.52	6.14	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.73	2.18	8.53	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.22	.67	1.58	.79	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.52	.84	1.10	2.41	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.54	.43	3.02	.08	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.70	1.07	6.24	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.95	1.44	.44	.79	1.99	12.97	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	6.99	21.21	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.27	1.08	3.97	1.77	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.92	1.25	1.63	4.43	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.56	.44	3.18	.09	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.84	1.15	5.79	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.63	1.04	.47	.83	1.20	9.48	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.91	7.77	15.53	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.25	1.17	4.82	2.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.53	.87	1.70	6.09	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62 AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.20	.26	0.00	0.00	.43	2.39	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.25	3.48	6.77	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.51	.77	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.24	.21	.04	1.46	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y62 AT ALTITUDE 13000-14000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06	1.05	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.86	.25	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.65	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y40 AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.40	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.40	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y40 AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.39	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTICN (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y40 AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.28	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE Y40 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.12	0.00	
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
180													

BEST AVAILABLE COPY

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC

	ALTITUDE BANDS 6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	6.82	7.52	8.95	8.51	5.30	1.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.06	1.43	.41	1.50	0.00	.67	.13	.10	0.00	.54	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.20	.42	.52	3.40	
-100	0.00	.35	.65	.36	.26	2.51	.88	2.25	1.49	.20	1.18	.60	
-60	0.00	0.00	.70	.91	.65	1.17	.35	.05	0.00	.16	.05	.30	
-20	0.00	0.00	.10	.12	0.00	.70	.65	.30	.66	.83	2.94	4.78	
20	0.00	0.00	.20	.50	.70	1.00	.25	.85	.25	.81	2.95	3.32	
60	0.00	0.00	0.00	0.00	0.00	.36	.62	.66	.56	.33	.22	.21	
100	0.00	0.00	.20	.91	.96	1.48	1.54	1.37	1.62	2.45	.86	.16	
140	0.00	.12	.95	1.39	.87	1.57	0.00	.29	0.00	.45	.50	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.06	1.43	1.57	1.50	0.00	.67	.13	.10	0.00	.96	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.72	2.69	.71	4.19	
-100	0.00	.57	2.12	1.64	.43	2.54	2.26	5.73	4.61	.20	1.18	1.06	
-60	0.00	0.00	1.03	1.90	1.14	1.28	.35	.05	0.00	.16	.05	.30	
-20	0.00	0.00	.10	.12	0.00	1.03	.65	.30	.66	1.35	6.35	10.36	
20	0.00	0.00	.46	1.92	1.36	1.66	.25	1.46	.47	2.27	6.65	8.69	
60	0.00	0.00	0.00	0.00	0.00	.40	.63	2.82	1.49	.39	.23	.54	
100	0.00	0.00	.20	.91	1.34	4.25	2.09	2.96	1.99	5.52	1.54	.24	
140	0.00	.12	3.24	1.40	2.09	1.85	0.00	.29	0.00	2.08	1.32	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.37	1.41	2.78	1.50	0.00	.67	.13	.09	0.00	1.52	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	5.05	.89	4.69	
-100	0.00	.76	3.61	3.01	.71	2.32	3.94	11.18	9.26	.31	1.10	1.50	
-60	0.00	0.00	1.32	3.30	1.85	1.54	.33	.09	0.00	.16	1.31	.26	
-20	0.00	0.00	.35	.12	0.00	1.34	.64	.27	.61	2.67	10.12	15.90	
20	0.00	0.00	.98	3.36	1.96	2.31	2.69	3.00	2.79	4.83	10.25	13.78	
60	0.00	0.00	.18	.13	0.00	.59	.81	5.09	2.42	.40	.31	.64	
100	0.00	0.00	.20	.85	1.68	6.98	2.64	4.53	2.31	8.86	2.25	1.59	
140	0.00	.12	5.78	1.26	3.27	1.97	0.00	.29	0.00	3.50	2.13	0.00	
180													

BEST AVAILABLE COPY

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC AT ALTITUDE 10000-11000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.55	1.08	3.21	1.15	0.00	.51	.10	.09	0.00	2.92	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	5.99	.90	4.30	
-100	0.00	.76	4.11	3.95	1.61	2.15	6.53	25.04	19.25	.34	.81	1.59	
-60	0.00	0.00	1.29	4.19	4.01	2.76	.24	.10	0.00	.13	2.06	.18	
-20	0.00	0.00	.49	.09	0.00	1.32	.53	.24	.57	3.21	13.79	26.51	
20	0.00	0.00	1.21	3.88	2.08	2.37	4.12	3.64	4.11	6.02	11.46	19.32	
60	0.00	0.00	.29	.21	0.00	1.20	.95	5.95	2.72	.33	.47	1.59	
100	0.00	0.00	.16	.58	1.67	7.93	3.40	4.95	2.21	11.87	2.60	3.26	
140	0.00	.09	8.10	1.02	3.59	1.68	0.00	.22	0.00	4.50	2.36	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC AT ALTITUDE 11000-12000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.56	.56	1.73	.60	0.00	.27	.05	.07	0.00	1.71	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.77	3.24	.47	2.14	
-100	0.00	.39	2.20	2.18	.99	1.09	3.78	15.11	11.53	.28	.39	.93	
-60	0.00	0.00	.67	2.62	2.48	1.64	.11	.09	0.00	.07	2.21	.04	
-20	0.00	0.00	.49	.05	0.00	.69	.33	.18	.45	2.43	7.67	15.06	
20	0.00	0.00	.88	2.08	1.09	1.26	4.35	2.76	4.05	4.17	6.09	12.09	
60	0.00	0.00	.31	.23	0.00	.76	.66	3.25	1.48	.17	.31	2.24	
100	0.00	0.00	.08	.36	.91	4.44	1.90	2.63	1.11	6.55	1.40	2.97	
140	0.00	.05	4.52	.54	1.90	.83	0.00	.12	0.00	2.41	1.25	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC AT ALTITUDE 12000-13000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	.01	.82	0.00	0.00	0.00	0.00	.04	0.00	.74	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.38	1.61	.20	.38	
-100	0.00	.18	1.05	1.05	.43	.40	1.71	6.43	4.92	0.00	.07	.37	
-60	0.00	0.00	.27	.90	1.05	.56	.02	0.00	0.00	0.00	0.00	.03	
-20	0.00	0.00	.01	0.00	0.00	.25	.07	.08	.20	.40	3.40	6.75	
20	0.00	0.00	.20	1.02	.52	.48	0.00	.45	.17	1.09	2.90	5.54	
60	0.00	0.00	0.00	0.00	0.00	.25	.09	1.55	.71	.05	.05	1.12	
100	0.00	0.00	0.00	.11	.37	2.13	.78	1.22	.40	2.99	.58	.35	
140	0.00	0.00	2.11	.20	.92	.32	0.00	0.00	0.00	1.18	.61	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE MSC AT ALTITUDE 13000-14000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	0.00	0.00	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.01	0.00	
-100	0.00	0.00	0.00	0.00	.01	.01	.02	.01	0.00	0.00	0.00	0.00	
-60	0.00	0.00	0.00	.01	.04	.01	0.00	0.00	0.00	0.00	0.00	0.00	
-20	0.00	0.00	0.00	0.00	0.00	0.00	.02	.02	.06	.01	0.00	0.00	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.41	
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.01	0.00	0.00	.43	
100	0.00	0.00	0.00	.01	.02	.07	.01	.01	0.00	0.00	0.00	0.00	
140	0.00	0.00	0.00	.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER

	ALTITUDE BANDS 6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	1900[illegible]
NORTH POLE	.42	.51	.98	.93	.95	1.03	.10	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER AT ALTITUDE 6000 -8000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.00	.03	.01	.03	0.00	.02	.14	0.00	0.00	.01	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.09	2.24	.86	.50	
-100	.00	.02	.09	.02	.11	.11	.25	1.17	1.61	3.83	4.19	.06	
-60	0.00	0.00	.11	.23	.11	.08	.03	.07	0.00	.01	.02	.01	
-20	0.00	0.00	.02	.01	0.00	.10	.26	.13	.24	1.49	2.89	1.36	
20	0.00	0.00	.01	.06	.04	.12	.03	.09	.22	1.17	.73	.67	
60	0.00	0.00	0.00	0.00	0.00	.00	.00	.00	.01	.00	.01	.02	
100	0.00	0.00	.03	.02	.01	.06	.02	.00	.00	.01	.00	0.00	
140	0.00	.01	.06	.04	.02	.02	.00	.01	0.00	.00	0.00	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER AT ALTITUDE 8000 -9000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.00	.03	.02	.03	0.00	.02	.14	0.00	0.00	.04	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.17	3.31	1.36	.60	
-100	.00	.03	.18	.06	.15	.15	.40	1.38	2.46	6.94	6.06	.09	
-60	0.00	0.00	.13	.33	.20	.10	.05	.08	0.00	.01	.03	.01	
-20	0.00	0.00	.02	.01	.00	.11	.28	.14	.24	2.27	5.16	1.96	
20	0.00	0.00	.03	.09	.05	.13	.04	.13	.32	1.78	1.33	1.19	
60	0.00	0.00	0.00	0.00	0.00	.00	.00	.00	.02	.01	.01	.02	
100	0.00	0.00	.03	.02	.02	.12	.02	.00	.00	.01	.00	0.00	
140	0.00	.01	.11	.05	.03	.02	.00	.01	0.00	.00	0.00	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER AT ALTITUDE 9000-10000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.02	.03	.05	.03	.02	.05	1.69	.27	.04	.21	
-140	0.00	0.00	0.00	0.00	0.00	.00	.01	.02	.75	10.30	4.19	1.24	
-100	.00	.04	.27	.28	.36	.60	1.05	2.56	6.00	13.62	11.67	.32	
-60	0.00	0.00	.16	.48	.49	.29	.18	.22	.17	.14	.53	1.45	
-20	0.00	0.00	.02	.01	.08	.45	1.18	2.74	3.66	7.26	11.97	3.15	
20	0.00	0.00	.04	.19	.24	.24	.99	1.14	1.91	5.97	4.37	1.73	
60	0.00	0.00	.00	.00	.00	.01	.02	.03	.09	.02	.02	.03	
100	0.00	0.00	.09	.13	.15	.21	.06	.02	.01	.01	.01	.01	
140	0.00	.01	.21	.15	.04	.02	.00	.01	.03	.06	.10	.06	
180													

BEST AVAILABLE COPY

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	.02	.02	.05	.02	.02	.04	1.65	.27	.04	.20
-140 / -100	0.00	0.00	0.00	0.00	0.00	.00	.01	.02	.72	9.71	3.99	1.15
-100 / -60	.00	.04	.26	.28	.34	.58	1.01	2.38	5.46	12.64	11.07	.32
-60 / -20	0.00	0.00	.14	.45	.47	.28	.18	.20	.17	.14	.53	1.45
-20 / 20	0.00	0.00	.02	.01	.08	.43	1.11	2.71	3.63	6.93	11.39	2.94
20 / 60	0.00	0.00	.04	.18	.23	.21	.98	1.12	1.86	5.68	4.21	1.59
60 / 100	0.00	0.00	.00	.00	.00	.01	.02	.03	.09	.01	.02	.03
100 / 140	0.00	0.00	.08	.13	.15	.20	.06	.02	.01	.01	.01	.01
140 / 180	0.00	.01	.19	.15	.03	.02	.00	.01	.03	.06	.10	.06

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	.02	.02	.06	.01	.02	.03	2.30	.39	.05	.21
-140 / -100	0.00	0.00	0.00	0.00	0.00	.00	.01	.03	.77	10.12	4.14	.94
-100 / -60	.00	.02	.15	.30	.36	.67	1.02	2.36	4.51	8.71	9.98	.39
-60 / -20	0.00	0.00	.10	.33	.41	.31	.21	.23	.25	.19	.74	2.10
-20 / 20	0.00	0.00	.01	.01	.11	.54	1.41	3.82	5.14	7.32	9.95	2.49
20 / 60	0.00	0.00	.01	.17	.28	.20	1.38	1.49	2.33	6.11	4.30	.76
60 / 100	0.00	0.00	.00	.01	.01	.01	.03	.05	.10	.02	.02	.03
100 / 140	0.00	0.00	.08	.16	.20	.16	.06	.03	.02	.00	.01	.01
140 / 180	0.00	.01	.14	.16	.02	.01	.00	.01	.04	.09	.14	.09

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	0.00	.00	.06	0.00	0.00	.10	.02	0.00	0.00	.42
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	1.37	16.91	6.96	2.96
-100 / -60	.00	.14	.69	.47	.43	.70	1.54	3.27	18.02	43.90	19.46	.23
-60 / -20	0.00	0.00	.31	1.05	1.08	.35	.15	.10	0.00	.02	.10	.01
-20 / 20	0.00	0.00	.01	.02	.03	.11	.25	.14	.18	11.78	15.60	5.19
20 / 60	0.00	0.00	.16	.25	.17	.20	.13	.36	1.45	8.55	7.98	6.50
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	.00	.01	.12	.02	.02	.02
100 / 140	0.00	0.00	.23	.10	.06	.40	.04	0.00	0.00	0.00	0.00	0.00
140 / 180	0.00	.04	.53	.22	.09	.04	.01	0.00	0.00	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE LER AT ALTITUDE 13000-14000 METERS

LONGITUDE BANDS	-60 / -50	-50 / -40	-40 / -30	-30 / -20	-20 / -10	-10 / 0	0 / 10	10 / 20	20 / 30	30 / 40	40 / 50	50 / 60
-180 / -140	0.00	0.00	0.00	.00	.01	0.00	0.00	.02	.00	0.00	0.00	.07
-140 / -100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.21	2.50	.96	.39
-100 / -60	.00	.01	.05	.06	.05	.10	.17	.43	3.02	6.15	2.01	.02
-60 / -20	0.00	0.00	.04	.10	.13	.05	.01	.01	0.00	.00	.01	.00
-20 / 20	0.00	0.00	.00	.00	.01	.01	.03	.01	.03	1.67	3.07	.52
20 / 60	0.00	0.00	.01	.02	.02	.03	.02	.03	.21	1.19	1.08	.96
60 / 100	0.00	0.00	0.00	0.00	0.00	0.00	.00	.00	.02	.00	.00	.00
100 / 140	0.00	0.00	.04	.01	.00	.02	.00	0.00	0.00	0.00	0.00	0.00
140 / 180	0.00	.00	.07	.03	.01	.00	.00	0.00	0.00	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE C50

	ALTITUDE BANDS												
	6000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000
NORTH POLE	.72	.98	1.75	2.63	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE C50 AT ALTITUDE 6000 -8000 METERS

LONGITUDE	LATITUDE BANDS											
BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.00	.03	.01	.03	0.00	.02	.14	0.00	0.00	.01	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.10	2.24	.87	.50	
-100	.00	.00	.06	.00	.03	.03	.12	1.16	1.66	3.85	4.27	.06	
-60	0.00	0.00	.03	.04	.02	.03	.01	.11	0.00	.02	.02	.01	
-20	0.00	0.00	.03	.01	0.00	.20	.53	.26	.49	3.14	6.29	3.00	
20	0.00	0.00	.02	.11	.08	.24	.07	.18	.44	2.42	1.65	1.59	
60	0.00	0.00	0.00	0.00	0.00	.01	.01	.06	.07	.02	.02	.06	
100	0.00	0.00	.02	.01	.01	.07	.08	.07	.12	.19	.01	.00	
140	0.00	.00	.05	.03	.01	.02	.00	.00	0.00	.02	.03	0.00	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE C50 AT ALTITUDE 8000 -9000 METERS

LONGITUDE	LATITUDE BANDS											
BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.00	.03	.02	.03	0.00	.04	.14	0.00	0.00	.10	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.40	5.47	2.20	1.02	
-100	.00	.01	.08	.02	.04	.08	.25	1.56	5.33	12.56	7.93	.10	
-60	0.00	0.00	.04	.07	.05	.04	.02	.12	0.00	.03	.04	.01	
-20	0.00	0.00	.03	.02	.01	.24	.62	.31	.51	7.89	17.36	5.27	
20	0.00	0.00	.08	.20	.14	.31	.11	.32	.95	5.85	5.17	4.62	
60	0.00	0.00	0.00	0.00	0.00	.01	.02	.10	.22	.04	.05	.07	
100	0.00	0.00	.06	.03	.02	.16	.14	.22	.25	.42	.03	.01	
140	0.00	.01	.13	.06	.03	.02	.00	.00	0.00	.06	.05	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE C50 AT ALTITUDE 9000-10000 METERS

LONGITUDE	LATITUDE BANDS											
BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.01	.03	.05	.03	.01	.06	1.73	.27	.05	.29	
-140	0.00	0.00	0.00	0.00	0.00	.00	.01	.02	.85	11.39	4.70	1.47	
-100	.00	.01	.16	.12	.14	.23	.53	2.16	7.23	17.04	13.93	.45	
-60	0.00	0.00	.06	.24	.22	.19	.16	.34	.34	.25	.91	2.41	
-20	0.00	0.00	.03	.03	.15	.97	2.51	5.78	7.64	16.92	30.27	7.61	
20	0.00	0.00	.12	.42	.49	.51	2.08	2.43	4.13	13.71	10.86	5.32	
60	0.00	0.00	.00	.01	.00	.01	.07	.31	.55	.09	.08	.10	
100	0.00	0.00	.08	.15	.20	.35	.22	.28	.40	.59	.05	.06	
140	0.00	.01	.21	.16	.05	.03	.01	.03	.05	.21	.22	.10	
180													

BEST AVAILABLE COPY

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE C50 AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60 to -50	-50 to -40	-40 to -30	-30 to -20	-20 to -10	-10 to 0	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60
-180 to -140	0.00	0.00	.01	.02	.08	.02	.01	.13	1.71	.27	.05	.67
-140 to -100	0.00	0.00	0.00	0.00	0.00	.00	.01	.03	2.19	25.25	10.27	3.53
-100 to -60	.00	.03	.23	.19	.20	.45	.99	3.61	24.12	54.05	27.26	.59
-60 to -20	0.00	0.00	.08	.35	.36	.22	.21	.33	.34	.29	.98	2.41
-20 to 20	0.00	0.00	.02	.04	.20	1.06	2.71	5.90	7.69	36.95	73.83	15.65
20 to 60	0.00	0.00	.32	.71	.73	.75	2.27	2.88	6.25	27.96	25.49	17.79
60 to 100	0.00	0.00	.00	.01	.00	.02	.09	.47	1.11	.17	.20	.13
100 to 140	0.00	0.00	.23	.21	.23	.63	.48	.95	.93	1.42	.10	.07
140 to 180	0.00	.03	.52	.29	.10	.04	.02	.03	.05	.34	.28	.10

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE C50 AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	LATITUDE BANDS -60 to -50	-50 to -40	-40 to -30	-30 to -20	-20 to -10	-10 to 0	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60
-180 to -140	0.00	0.00	.02	.02	.04	.01	.02	.04	2.36	.40	.07	.26
-140 to -100	0.00	0.00	0.00	0.00	0.00	.00	.01	.02	.60	8.22	3.38	.57
-100 to -60	0.00	.00	.12	.15	.15	.22	.38	.95	2.47	4.46	7.67	.48
-60 to -20	0.00	0.00	.03	.23	.23	.22	.19	.35	.49	.33	1.25	3.48
-20 to 20	0.00	0.00	.00	.01	.20	1.11	2.91	8.01	10.42	12.27	15.17	2.92
20 to 60	0.00	0.00	.00	.28	.52	.38	2.87	3.04	4.56	10.87	7.24	.16
60 to 100	0.00	0.00	.00	.01	.00	.01	.08	.29	.44	.05	.06	.05
100 to 140	0.00	0.00	.05	.18	.25	.22	.10	.06	.20	.17	.03	.07
140 to 180	0.00	.00	.10	.15	.03	.01	.01	.04	.08	.19	.24	.14

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF

ALTITUDE BANDS

	6000/8000	8000/9000	9000/10000	10000/11000	11000/12000	12000/13000	13000/14000	14000/15000	15000/16000	16000/17000	17000/18000	18000/19000
NORTH POLE	.47	.34	.84	.86	.87	.51	.05	0.00	0.00	0.00	0.00	0.00
SOUTH POLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF AT ALTITUDE 6000 -8000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60/-50	-50/-40	-40/-30	-30/-20	-20/-10	-10/0	0/10	10/20	20/30	30/40	40/50	50/60
-180/-140	0.00	0.00	.00	.03	.01	.04	0.00	.05	.18	0.00	0.00	.19
-140/-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	.61	8.79	3.41	1.53
-100/-60	.00	.01	.04	.03	.05	.12	.26	1.75	8.78	19.67	9.88	.11
-60/-20	0.00	0.00	.04	.08	.07	.03	.02	.05	.00	.01	.05	.01
-20/20	0.00	0.00	.01	.00	.00	.04	.10	.05	.08	1.55	3.00	.81
20/60	0.00	0.00	.01	.03	.03	.06	.02	.05	.23	1.18	1.00	.82
60/100	0.00	0.00	0.00	0.00	0.00	.01	.03	.14	.25	.05	.07	.07
100/140	0.00	0.00	.06	.02	.01	.11	.22	.48	.46	.64	.03	.02
140/180	0.00	.01	.11	.05	.02	.01	.00	.00	0.00	.06	.07	0.00

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF AT ALTITUDE 8000 -9000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60/-50	-50/-40	-40/-30	-30/-20	-20/-10	-10/0	0/10	10/20	20/30	30/40	40/50	50/60
-180/-140	0.00	0.00	.00	.03	.01	.04	0.00	.02	.17	0.00	0.00	.03
-140/-100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.14	3.14	1.28	.67
-100/-60	.00	.00	.03	.01	.03	.03	.15	1.11	1.98	6.26	6.03	.08
-60/-20	0.00	0.00	.03	.05	.03	.02	.01	.05	0.00	.01	.03	.01
-20/20	0.00	0.00	.00	.00	0.00	.03	.09	.04	.06	.56	1.35	.55
20/60	0.00	0.00	.01	.03	.01	.04	.01	.04	.10	.47	.33	.31
60/100	0.00	0.00	0.00	0.00	0.00	.00	.01	.09	.14	.02	.02	.02
100/140	0.00	0.00	.02	.01	.01	.10	.12	.12	.20	.37	.03	.00
140/180	0.00	.00	.05	.02	.01	.01	.00	.00	0.00	.06	.06	0.00

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF AT ALTITUDE 9000-10000 METERS

LATITUDE BANDS

LONGITUDE BANDS	-60/-50	-50/-40	-40/-30	-30/-20	-20/-10	-10/0	0/10	10/20	20/30	30/40	40/50	50/60
-180/-140	0.00	0.00	.01	.04	.03	.04	.01	.04	2.13	.34	.07	.28
-140/-100	0.00	0.00	0.00	0.00	0.00	.00	.01	.01	.69	9.75	3.95	1.31
-100/-60	.00	.01	.08	.11	.14	.19	.44	1.72	3.87	12.64	13.05	.34
-60/-20	0.00	0.00	.04	.11	.11	.09	.08	.11	.08	.10	.41	1.15
-20/20	0.00	0.00	.01	.00	.02	.14	.38	.88	1.13	2.08	3.67	1.47
20/60	0.00	0.00	.02	.06	.06	.07	.35	.37	.62	1.61	1.22	.54
60/100	0.00	0.00	.00	.00	.00	.01	.05	.32	.50	.08	.04	.05
100/140	0.00	0.00	.03	.14	.20	.35	.23	.21	.39	.70	.06	.04
140/180	0.00	.01	.13	.12	.04	.02	.02	.04	.06	.29	.30	.13

BEST AVAILABLE COPY

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF AT ALTITUDE 10000-11000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.01	.02	.03	.03	.01	.06	2.08	.34	.07	.38	
-140	0.00	0.00	0.00	0.00	0.00	.00	.01	.02	.91	10.77	4.07	1.45	
-100	.00	.01	.08	.12	.14	.24	.42	1.59	6.69	18.66	13.09	.33	
-60	0.00	0.00	.04	.12	.13	.09	.08	.10	.08	.10	.42	1.15	
-20	0.00	0.00	.00	.00	.02	.14	.37	.85	1.08	2.51	4.18	1.52	
20	0.00	0.00	.02	.05	.05	.07	.35	.37	.64	1.59	1.39	.81	
60	0.00	0.00	.00	.00	.00	.01	.05	.28	.51	.09	.05	.08	
100	0.00	0.00	.04	.14	.20	.35	.26	.39	.41	.74	.06	.03	
140	0.00	.01	.15	.13	.05	.02	.02	.04	.06	.30	.30	.13	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF AT ALTITUDE 11000-12000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	.01	.02	.04	.02	.02	.05	2.90	.49	.10	.40	
-140	0.00	0.00	0.00	0.00	0.00	.00	.01	.02	.95	14.20	5.92	1.29	
-100	.00	.00	.07	.16	.17	.26	.55	1.99	6.11	13.48	13.61	.32	
-60	0.00	0.00	.03	.09	.13	.10	.09	.11	.13	.14	.56	1.66	
-20	0.00	0.00	.00	.00	.04	.18	.46	1.25	1.67	2.55	4.05	1.45	
20	0.00	0.00	.01	.07	.10	.07	.49	.50	.88	2.47	1.72	.44	
60	0.00	0.00	.00	.00	.00	.01	.08	.44	.59	.09	.07	.25	
100	0.00	0.00	.06	.19	.27	.33	.21	.25	.53	.60	.04	.28	
140	0.00	.00	.14	.17	.05	.02	.02	.05	.09	.29	.36	.19	
180													

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF AT ALTITUDE 12000-13000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	.00	.02	0.00	0.00	.05	.01	0.00	0.00	.35	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.01	1.11	15.54	6.50	2.29	
-100	.00	.01	.07	.05	.06	.17	.46	2.09	15.24	35.71	15.93	.18	
-60	0.00	0.00	.03	.11	.12	.04	.03	.03	.00	.00	.07	.00	
-20	0.00	0.00	.00	.00	.01	.02	.05	.04	.09	2.54	5.55	1.05	
20	0.00	0.00	.03	.05	.05	.04	.03	.08	.39	2.25	1.98	1.43	
60	0.00	0.00	0.00	0.00	0.00	.01	.04	.26	.51	.07	.11	.11	
100	0.00	0.00	.09	.03	.02	.23	.33	.81	.78	1.11	.06	.03	
140	0.00	.01	.18	.08	.03	.01	.00	0.00	0.00	.15	.08	0.00	
180													

1975 WORLDWIDE FLIGHT HOUR DISTRIBUTION (USING JUN 1975 DATA BASE)

NON POLAR FLIGHT HOURS SPENT BY AIRCRAFT TYPE GLF AT ALTITUDE 13000-14000 METERS

LONGITUDE BANDS	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
-180	0.00	0.00	0.00	.00	.01	0.00	0.00	.01	.00	0.00	0.00	.25	
-140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00	.19	3.72	1.67	.32	
-100	.00	.00	.00	.01	.01	.03	.10	.52	3.08	5.61	2.73	.02	
-60	0.00	0.00	.00	.01	.01	.01	.00	.00	.00	.00	.01	0.00	
-20	0.00	0.00	0.00	0.00	.01	.00	.00	.02	.05	.38	.89	.10	
20	0.00	0.00	0.00	.01	.02	.01	.01	.01	.09	.63	.42	.18	
60	0.00	0.00	0.00	0.00	0.00	.00	.01	.08	.08	.01	.03	.02	
100	0.00	0.00	.02	.01	.00	.01	.04	.13	.19	.16	.00	.01	
140	0.00	.00	.03	.02	.00	.00	0.00	0.00	0.00	.00	0.00	0.00	
180													

OTAL FLIGHT HOURS SPENT BY AIRCRAFT TYPE

L10	681.6	707	7676.7	727	5072.0	737	2158.0	747	2978.9	D10	2094.7	A38	23.0	TRD	157.7
F28	390.4	T34	446.2	T54	702.3	Y62	242.7	Y86	0.0	Y40	5.4	7X7	0.0	745	0.0
DCX	0.0	MSC	962.8	LER	602.6	C50	845.3	GLW	485.8	SST	0.0				

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16. Abstract

The level of international air traffic on a world-wide basis is analyzed for the base year of 1975 and forecast for the years of 1980, 1985, and 1990. An econometric model is used to forecast flight activity using regional economic and population data and data on fuel prices and other aircraft operating costs. Other models transform these forecasts into estimates of aircraft flight hours at various altitudes over areas of the globe. A special model was devised which probabilistically assigns flight-hour activity to specific aircraft types in future years as fleet composition changes. The evidence illustrates the prominence of U.S., European, and U.S.-European traffic in total activity. It also indicated the gradual transition to wide-body aircraft and the gradual phasing out of four-engine, narrow-body transports.

Note: This research uses certain models and techniques developed by SRI in a previous effort. See report FAA-RD-76-15, April 1976.

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